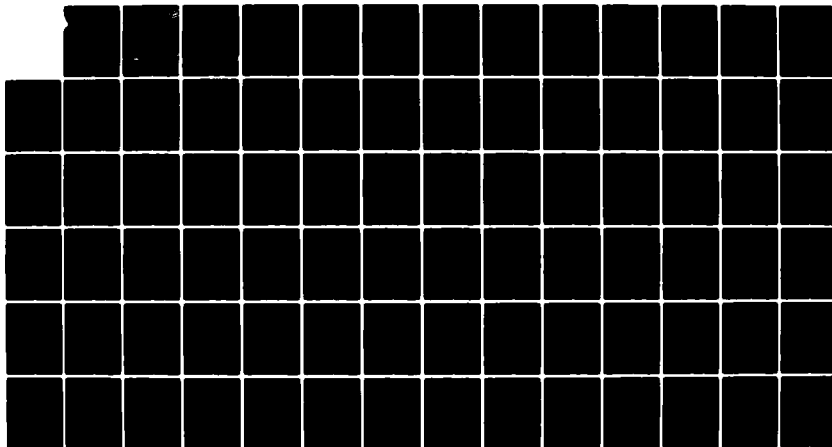


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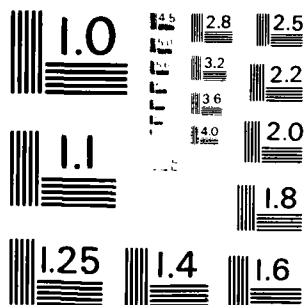
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## HIGH REYNOLDS NUMBER CYLINDER FLOW STUDIES

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# HIGH REYNOLDS NUMBER CYLINDER FLOW STUDIES

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 SFRC NUMBER N00014-81-K-0479

DEPARTMENT OF PHYSICS  
 ALABAMA A. & M. UNIVERSITY  
 NORMAL, AL 35762

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Cylinder Flow                      Boundary Layer Flow                      Turbulence Wind Tunnel Data                      Roughness Effects                      Cylinder Drag		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This document contains a description of a series of wind tunnel tests conducted in the NASA-Ames 12-foot pressurized wind tunnel. Experiments were conducted on smooth and rough cylinders at Reynolds numbers that ranged from $10^5$ to $7 \times 10^6$ . Roughnesses were obtained by using four sizes of wire mesh to cover the smooth cylinder. Sample results are included, but the complete data set is the subject of a forthcoming report.  10000-75 75000-75		

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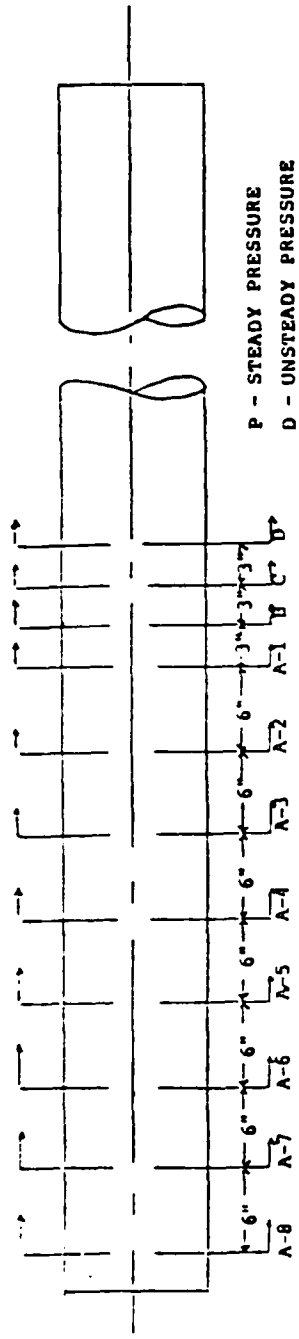
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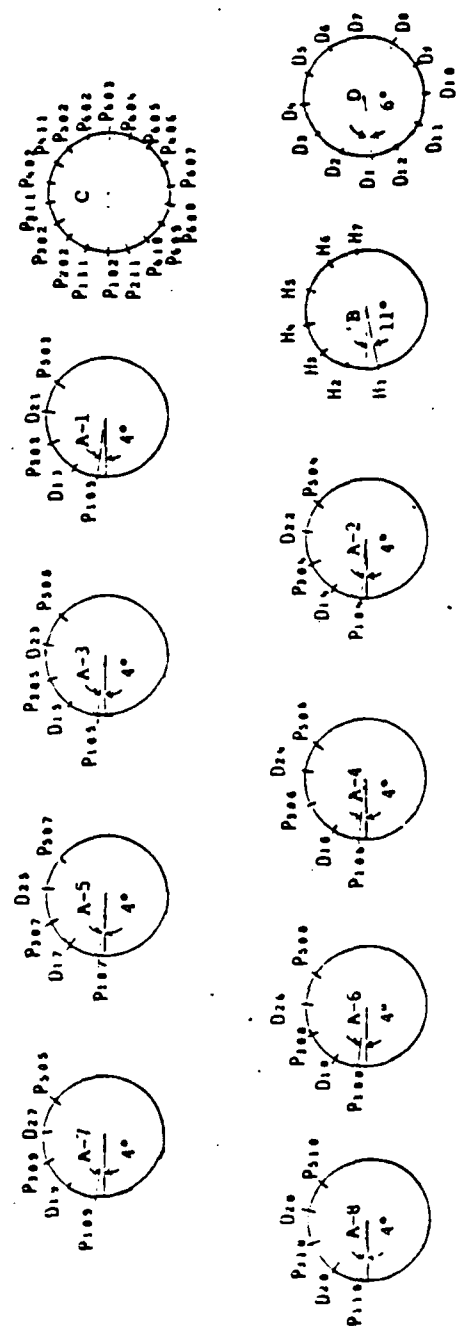
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## CONTENTS

- TEST SETUP
- RUN MATRIX
- MEAN PRESSURE DATA
- INTEGRATED RESULTS
- BOUNDARY LAYER SURVEYS
- DYNAMIC DATA
- TRANSITION EXPERIMENTS
- CONCLUDING REMARKS



P - STEADY PRESSURE  
 D - UNSTEADY PRESSURE  
 H - HOT WIRE



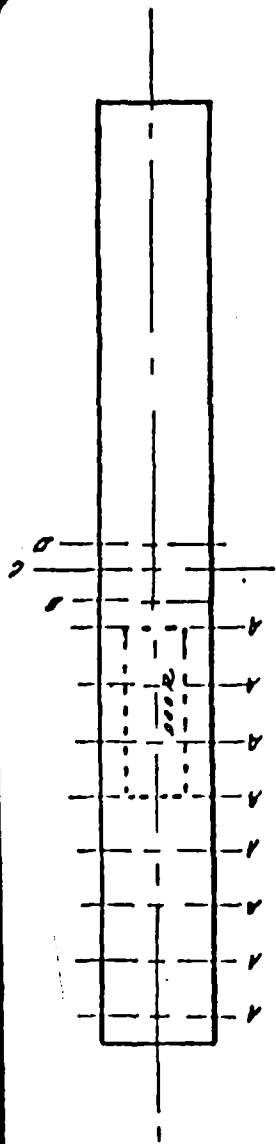
SECTION A-1 to A-8, B, D: ORIFICES LOCATED 30° APART

SECTION C: ORIFICES LOCATED 20° APART

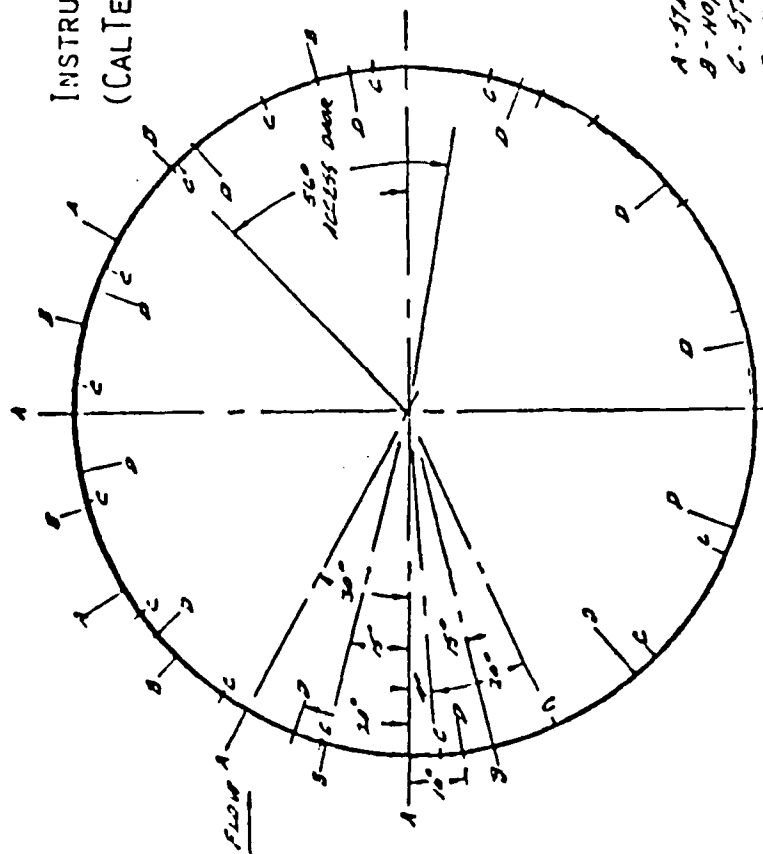
Model Instrumentation at 0 Degrees Roll Angle







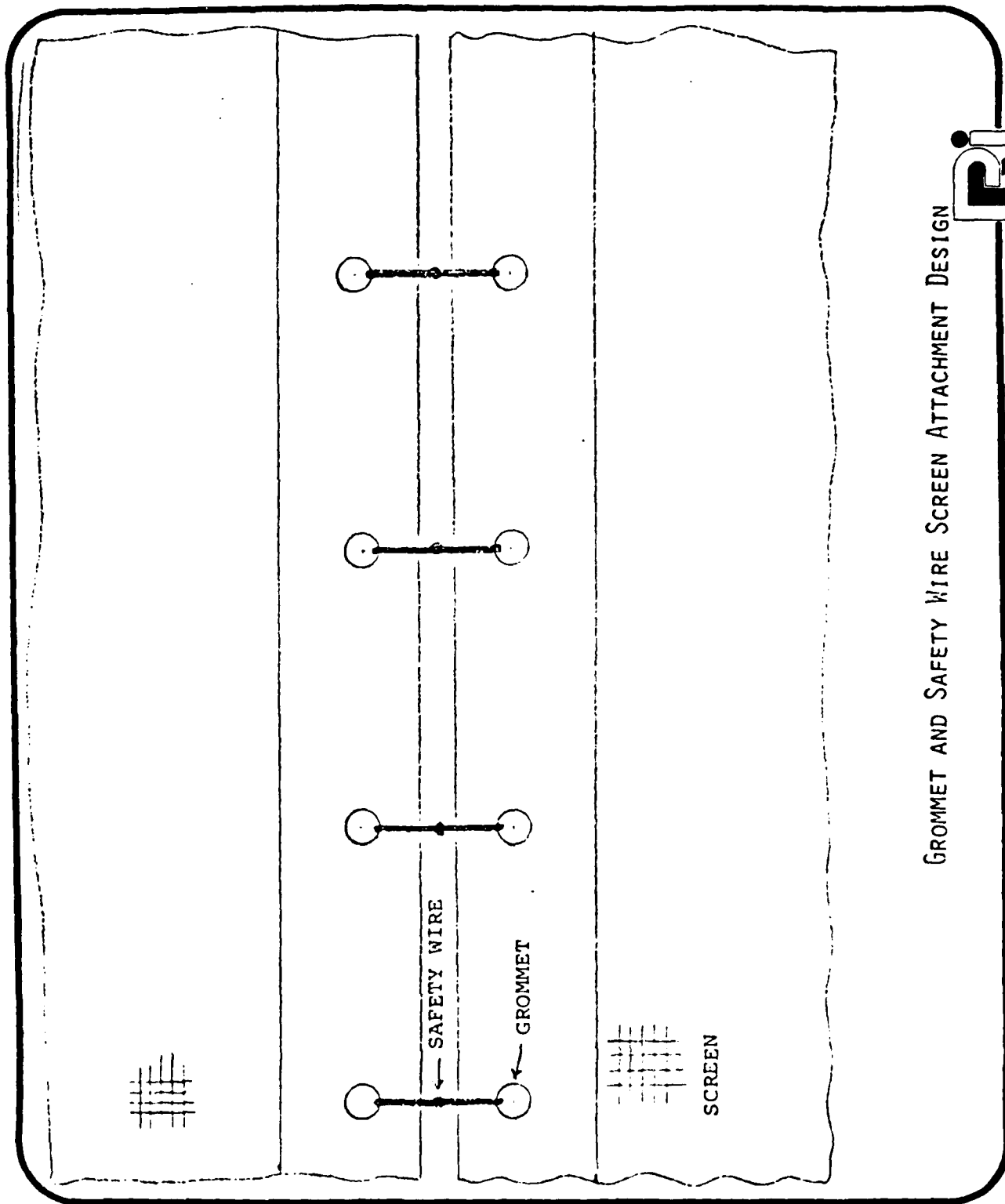
INSTRUMENTATION LOCATION-REAR VIEW  
(CALTECH TEST)



- A-STATIC TAPS
- B-HOT WIRES
- C-STATIC TAPS
- D-UNSTEADY TAPS

INSTRUMENTATION LOCATION-END VIEW  
(CALTECH TEST)





GROMMET AND SAFETY WIRE SCREEN ATTACHMENT DESIGN



WIRE DIAMETER (INCH)	MESH	% OPEN	k/d
0.0016	250	36	$3 \times 10^{-4}$
0.0065	60	37.5	$10^{-3}$
<del>.0075</del>	<del>60</del>	<del>30.5</del>	$1.2 \times 10^{-3}$
0.063	6	38.9	$10^{-2}$
<del>0.063</del>	<del>8</del>	<del>24.6</del>	<del><math>10^{-2}</math></del>

Table 1. Simulated Roughnesses

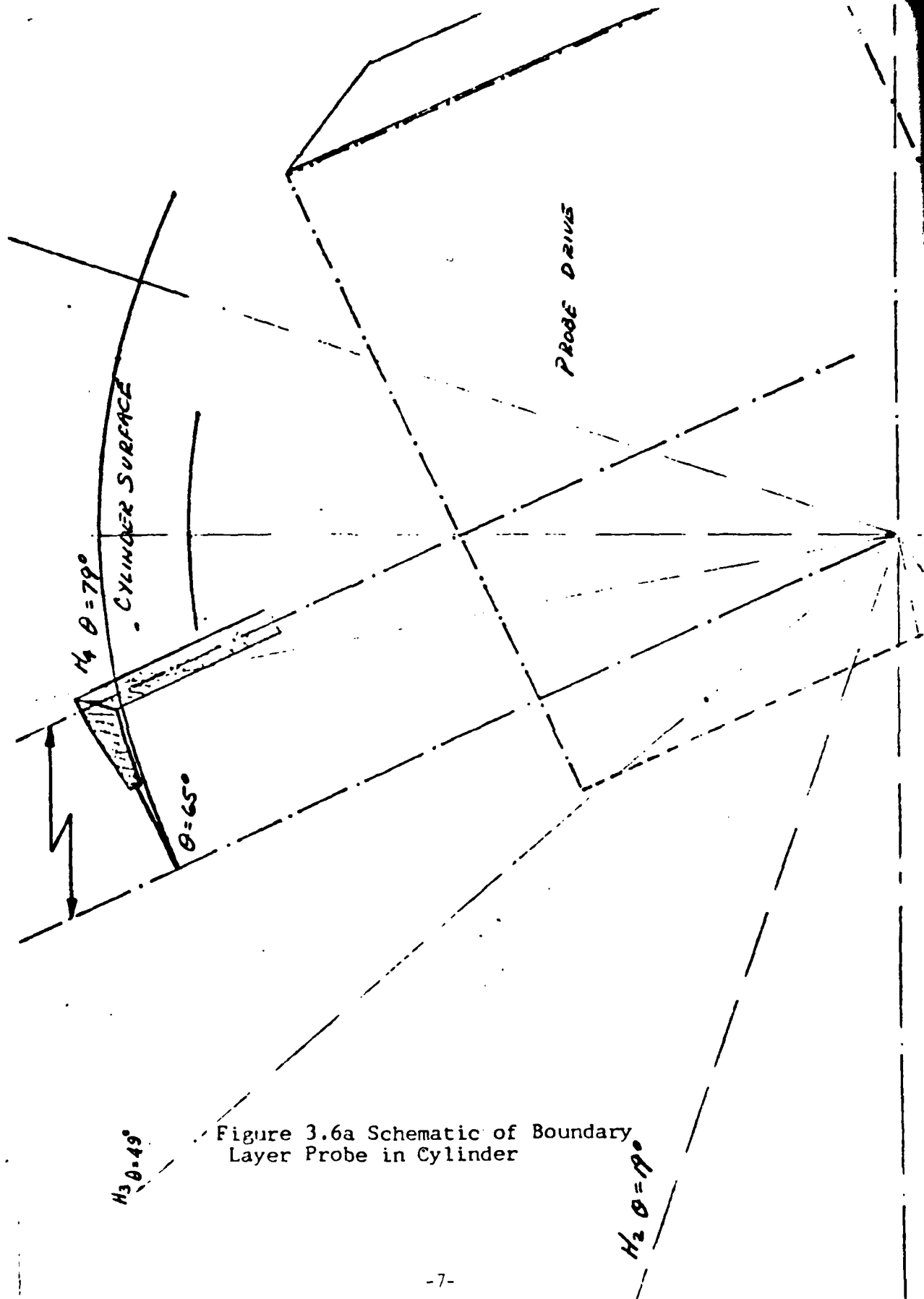


Figure 3.6a Schematic of Boundary Layer Probe in Cylinder

# Assembled Unit

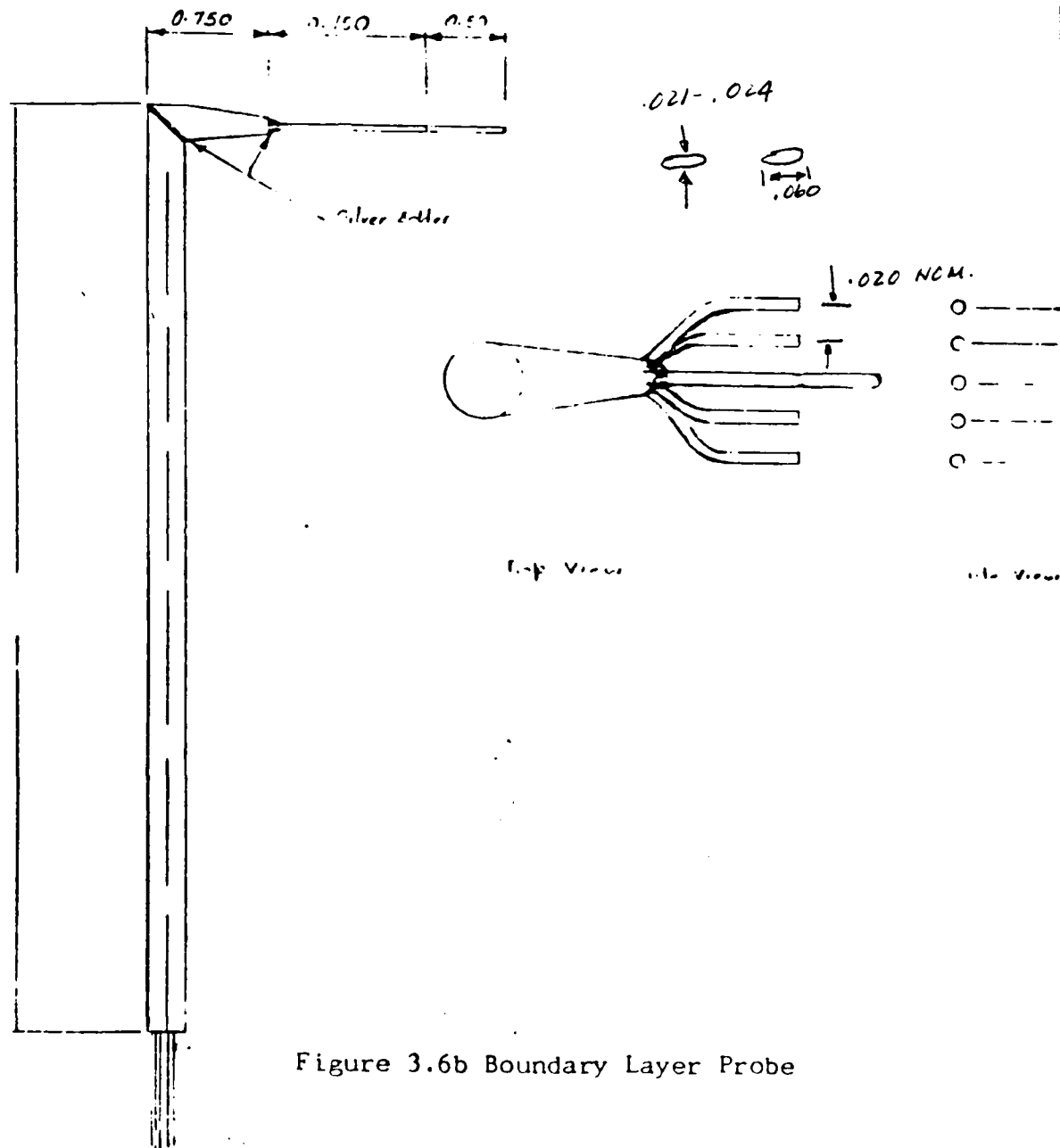


Figure 3.6b Boundary Layer Probe

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

**Aeronautics Division**

Experimental Investigations Branch

Model: FAR CYLINDER

Test No. 226-12

### TABLE II - Key to Configurations

[illegible]

SUN	MON	TUES	WED	THURS	FRI	SAT
9 MAY	10 <sup>129</sup>	11 <sup>130</sup>	12 <sup>131</sup>	13 <sup>132</sup>	14 <sup>133</sup>	15 <sup>134</sup>
		MODEL CHECKOUT	INSTALLATION CHECKOUT	SHAKE DOWN	SMOOTH MODEL	
16	17 <sup>136</sup>	18 <sup>137</sup>	19 <sup>138</sup>	20 <sup>139</sup>	21 <sup>140</sup>	22 <sup>141</sup>
	SMOOTH HYSTERESIS Ran 3/8-9	SMOOTH BL SURVEY Smooth 5-9	ROUGH K/D=BE-4 Smooth 12-25	MODEL Smooth 28	VARY TUNNEL SPEED Smooth 31-49	
23	24 <sup>143</sup>	25 <sup>144</sup>	26 <sup>145</sup>	27 <sup>146</sup>	28 <sup>147</sup>	29 <sup>148</sup>
30	31 <sup>150</sup>	Flow Visuali- zation	MODEL K/D Smooth	Smooth BL Survey	4/11 = 10 <sup>-2</sup> Rough Model	
		HOLIDAY				
JUNE		1 <sup>152</sup>	2 <sup>153</sup>	3 <sup>154</sup>	4 <sup>155</sup>	5 <sup>156</sup>
		ROUGH k/d = 10 <sup>-2</sup> Const press. vary 10 <sup>-4</sup> ; BL	MODEL K/D = 10 <sup>-2</sup> BL Survey	10 <sup>-3</sup> - 10 <sup>-4</sup> 3 x 10 <sup>-9</sup>	3 x 10 <sup>-4</sup> MODEL DISASSEMBLY	
60	7 <sup>157</sup>	8 <sup>158</sup>	9 <sup>159</sup>	10 <sup>160</sup>	11 <sup>161</sup>	12 <sup>162</sup>
	3 x 10 <sup>-4</sup>	3 x 10 <sup>-4</sup> BL Survey	12 x 10 <sup>-3</sup> Rotation; Dynamics	1.2 x 10 <sup>-3</sup> BL Probe last, Surveys	Continue 162 1.2 x 10 <sup>-3</sup> BL Model MIN Disassembly 2nd Shift	

FIGURE 6.1 TWELVE-FOOT PRESSURE TUNNEL TEST SCHEDULE

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EXPERIMENTAL INVESTIGATIONS BRANCH

TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TO	CONF	ALPHA	MACHU	RN/FT	PT	QIU	PLU	TTF	PROBE DATE	FMT
5	1	5	1	VARY	0.235	7.474	VARY	387.8	VARY	87.7	518	1
6	1	5	1	VARY	0.237	6.547	VARY	VARY	VARY	50.9	518	1
7	1	5	1	VARY	0.240	5.498	7858.9	305.1	7549.4	93.5	518	1
8	1	5	1	VARY	0.239	4.747	6589.1	254.0	8331.4	94.0	518	1
9	1	5	1	VARY	0.235	3.788	5223.8	200.8	VARY	90.5	518	1
12	1	5	1	VARY	0.240	2.877	3890.3	151.2	3736.9	84.5	519	1
13	1	5	1	VARY	0.240	2.430	3299.8	127.6	3170.4	85.2	519	1
14	1	5	1	VARY	0.241	1.917	2587.3	100.9	2484.9	84.3	519	1
15	1	5	1	VARY	0.242	1.454	1950.6	77.1	1872.5	84.4	519	1
16	1	5	1	VARY	0.243	1.220	1632.2	64.6	1566.7	83.7	519	1
17	1	5	1	VARY	0.239	0.967	1306.9	50.4	1255.8	82.6	519	1
18	1	5	1	VARY	0.239	0.858	1161.1	44.7	1115.7	82.7	519	1
19	1	5	1	VARY	0.241	0.777	1041.9	40.7	1000.6	82.0	519	1
20	1	5	1	VARY	0.243	0.669	891.3	35.2	855.5	81.5	519	1
21	1	5	1	VARY	0.244	0.392	516.6	20.7	495.6	79.1	519	1
22	1	5	1	VARY	0.243	0.489	647.7	25.8	621.6	81.1	519	1
23	1	5	1	VARY	0.242	0.584	780.3	30.7	749.1	81.9	519	1
25	1	81	1	9.96	0.247	VARY	VARY	VARY	VARY	VARY	519	2
28	1	33	1	9.95	0.054	0.205	VARY	2.4	VARY	VARY	520	2
29	1	24	1	9.95	0.145	0.380	VARY	11.6	VARY	63.4	520	2
31	2	214	1	9.97	VARY	0.438	VARY	VARY	VARY	VARY	521	2
33	1	5	1	VARY	0.145	0.292	623.0	9.0	613.9	68.3	521	1
34	1	5	1	VARY	0.145	0.297	632.3	9.1	623.1	68.0	521	1
35	1	5	1	VARY	0.147	0.314	658.5	9.8	648.6	68.2	521	1
36	1	5	1	VARY	0.147	0.341	715.5	10.7	704.8	68.9	521	1
37	1	5	1	VARY	0.147	0.361	757.1	11.3	745.7	68.9	521	1
38	1	5	1	VARY	0.147	0.372	781.7	11.6	770.0	68.7	521	1
39	1	5	1	VARY	0.148	0.385	804.3	12.1	792.2	68.6	521	1
40	1	5	1	VARY	0.147	0.393	823.8	12.3	811.5	68.5	521	1
41	1	5	1	VARY	0.147	0.398	833.0	12.5	820.5	68.4	521	1
42	1	5	1	VARY	0.148	0.405	843.5	12.7	830.7	68.3	521	1
43	1	5	1	VARY	0.147	0.413	862.7	12.9	849.7	68.4	521	1
44	1	5	1	VARY	0.149	0.454	942.5	14.4	928.1	69.4	521	1



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MODEL: FAR CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

PIJN	SFQ FROM	SFQ TO	CONF	ALPHA	MACHU	RN/FT	PT	QTU	PIU	TTF	PROBE	DATE	FMT
45	1	5	1	VARY	0.146	0.407	854.5	12.5	841.9	66.3		521	1
46	1	5	1	VARY	0.146	0.369	841.2	12.3	828.9	67.0		521	1
47	1	5	1	VARY	0.145	0.389	819.4	11.9	807.5	66.7		521	1
48	1	5	1	VARY	0.146	0.381	797.5	11.8	785.7	66.5		521	1
49	1	5	1	VARY	0.146	0.370	778.7	11.4	767.2	66.4		521	1
51	1	100	1	10.0	0.061	0.415	2101.0	VARY	2095.3	74.9		524	2
52	1	5	1	VARY	0.076	0.514	2100.6	8.4	2092.2	73.6		524	1
53	1	5	1	VARY	0.067	0.452	2100.6	6.5	2094.1	73.5		524	1
54	1	5	1	VARY	0.063	0.427	2100.6	5.8	2094.8	73.4		524	1
55	1	5	1	VARY	0.060	0.411	2100.6	5.4	2095.2	73.2		524	1
56	1	5	1	VARY	0.060	0.408	2100.6	5.3	2095.3	73.0		524	1
57	1	5	1	VARY	0.057	0.390	2100.6	4.8	2095.8	72.8		524	1
58	1	5	1	VARY	0.057	0.389	2100.6	4.8	2095.8	72.6		524	1
59	1	5	1	VARY	0.056	0.381	2100.6	4.6	2096.0	72.4		524	1
60	1	5	1	VARY	0.054	0.368	2100.6	4.3	2096.3	72.3		524	1
61	1	5	1	VARY	0.053	0.358	2100.6	4.1	2096.5	72.2		524	1
62	1	5	1	VARY	0.047	0.318	2099.9	3.2	2096.7	71.9		524	1
63	1	5	1	VARY	0.052	0.358	2099.9	4.0	2095.8	71.7		524	1
64	1	5	1	VARY	0.054	0.369	2099.9	4.3	2095.6	71.6		524	1
65	1	5	1	VARY	0.055	0.378	2099.9	4.5	2095.4	71.4		524	1
66	1	5	1	VARY	0.057	0.388	2099.9	4.7	2095.1	71.2		524	1
67	1	5	1	VARY	0.057	0.391	2099.9	4.8	2095.1	71.0		524	1
68	1	5	1	VARY	0.060	0.410	2099.9	5.3	2094.6	70.8		524	1
69	1	5	1	VARY	0.061	0.416	2100.0	5.4	2094.6	70.7		524	1
70	1	5	1	VARY	0.063	0.430	2100.6	5.8	2094.8	70.5		524	1
71	1	5	1	VARY	0.067	0.461	2100.6	6.6	2093.9	70.3		524	1
72	1	5	1	VARY	0.076	0.519	2100.7	8.4	2092.3	70.2		524	1
73	1	5	1	VARY	0.055	0.380	2101.3	4.5	2096.8	69.8		524	1
74	1	5	1	VARY	0.054	0.370	2101.3	4.3	2097.0	69.5		524	1
75	1	5	1	VARY	0.053	0.361	2102.0	4.1	2098.0	69.2		524	1
76	1	5	1	VARY	0.052	0.358	2102.0	4.0	2098.0	69.0		524	1
77	1	5	1	VARY	0.051	0.351	2102.0	3.8	2098.2	68.7		524	1
78	1	5	1	VARY	0.051	0.350	2102.0	3.8	2098.2	68.5		524	1

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MODEL: FAP CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

PUN	SEQ FROM	SEQ TO	CONF	ALPHA	MACHU	RN/FT	PT	CIU	PLU	TTF	PROBE DATE	FMT
79	1	5	1	VARY	0.049	0.227	2102.0	3.5	2098.5	68.2	524	1
80	1	5	1	VARY	0.049	0.337	2102.6	3.5	2099.1	68.0	524	1
81	1	5	1	VARY	0.047	0.226	2102.7	3.3	2099.4	67.7	524	1
82	1	5	1	VARY	0.047	0.221	2102.7	3.2	2099.5	67.5	524	1
83	1	196	1	9.99 VARY	0.384	VARY	VARY	VARY	VARY	66.2	524	2
84	2	18	1	-0.00	0.054	0.369	2102.7	4.2	2098.5	68.5	524	2
85	1	4	1	-0.00	0.059	0.405	2102.7	5.2	2097.5	69.7	524	2
86	1	3	1	0.00	0.071	0.489	2102.7	7.5	2095.2	70.4	524	2
87	1	5	1	0.00	0.052	0.358	2102.7	4.0	2098.7	70.8	524	2
88	4	26	1	VARY	0.041	0.277	2101.7	2.6	2099.1	VARY	524	2
89	1	114	1	0.01	0.052	0.356	2100.8	4.1	2096.7	73.4	525	2
91	1	5	1	VARY	0.248	7.765	10468.9	431.4	10030.8	95.7	526	1
92	1	5	1	VARY	0.248	6.882	9288.1	382.5	8894.8	96.0	526	1
93	1	5	1	VARY	0.247	5.902	8018.7	329.2	7684.5	98.2	526	1
94	1	5	1	VARY	0.247	4.510	6640.0	272.1	6363.7	95.8	526	1
95	1	5	1	VARY	0.248	3.977	5327.0	219.0	5104.6	92.4	526	1
96	1	5	1	VARY	0.248	2.953	3920.7	161.3	3756.9	88.6	526	1
97	1	5	1	VARY	0.248	2.474	3279.0	135.2	3141.8	88.3	526	1
98	1	5	1	VARY	0.248	1.974	2606.9	107.4	2497.8	86.6	526	1
99	1	5	1	VARY	0.249	1.478	1938.5	80.3	1857.0	84.8	526	1
100	1	5	1	VARY	0.249	1.232	1608.8	67.1	1540.7	84.1	526	1
101	1	5	1	VARY	0.248	1.002	1307.5	54.0	1252.6	82.2	526	1
102	1	5	1	VARY	0.250	0.894	1159.4	48.5	1110.1	81.9	526	1
103	1	5	1	VARY	0.249	0.788	1023.0	42.5	979.8	81.0	526	1
104	1	5	1	VARY	0.248	0.689	895.7	37.0	858.1	80.4	526	1
105	2	5	1	VARY	0.247	0.594	773.6	31.7	741.4	79.5	526	1
106	1	5	1	VARY	0.247	0.496	644.5	26.4	617.6	78.6	526	1
108	1	5	1	VARY	0.249	0.397	511.6	21.2	490.1	78.3	526	1
109	3	57	1	VARY	0.248	VARY	VARY	VARY	VARY	89.3	526	2
112	1	5	11	VARY	0.248	7.791	10470.3	430.8	10032.9	94.0 *****	527	1
113	1	5	11	VARY	0.247	7.682	10450.1	427.3	10016.2	98.0 0.033	527	1
114	1	5	11	VARY	0.247	7.650	10457.6	428.1	10022.9	100.3 VARY	527	1
115	1	12	11	0.03	0.247	7.559	10461.2	428.5	10026.1	105.9 0.011	527	2

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MODEL: FAF CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TC	CONF	ALPHA	MACHU	RN/FT	PT	CIU	PLU	TIF	PROBE DATE	FMT
116	1	20	11	20.1	0.247	7.502	10451.3	427.1	10017.6	108.4	0.017	527 2
117	1	20	11	25.2	VARY	VARY	VARY	VARY	VARY	110.5	0.023	527 2
118	1	20	11	25.2	0.248	5.923	9176.3	327.6	7833.4	106.6	0.024	527 2
119	1	20	11	20.1	0.248	5.890	8153.6	325.8	7812.6	108.0	0.023	527 2
120	1	19	11	10.0	0.249	5.878	8130.5	327.6	7787.7	108.7	0.017	527 2
121	1	17	11	0.03	0.248	5.922	8223.5	340.0	7878.3	109.6	0.014	527 2
122	1	16	11	0.02	0.248	4.782	6581.1	271.7	6305.2	105.3	0.011	527 2
123	1	19	11	20.1	0.249	4.769	6562.6	272.5	6285.9	106.4	0.022	527 2
124	1	22	11	25.2	0.249	4.739	6532.6	270.7	6257.8	106.7	0.023	527 2
125	1	10	11	0.02	0.248	2.984	4057.6	166.8	3888.2	98.9	0.005	527 2
126	1	22	11	20.1	0.248	2.980	4047.6	167.2	3877.8	99.4	0.018	527 2
127	1	22	11	10.0	0.248	2.968	4029.0	166.6	3859.8	99.4	0.017	527 2
128	1	22	11	25.3	0.248	2.958	4010.9	165.9	3842.4	99.0	0.022	527 2
129	1	1	11	25.0	0.249	2.957	3998.9	166.1	3830.2	98.7	0.019	527 2
130	1	5	11	VARY	0.249	2.951	3990.6	165.5	3822.5	98.4	0.019	527 1

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MODEL: FAP CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TO	CONF	ALPHA	MACHU	RN/FT	PT	QIU	PIU	TTF	PROBE	DATE	FMT
131	5	7	4	0.07	0.168	5.453	10341.0	200.7	10143.2	82.2	*****	528	1
132	1	5	4	VARY	0.198	6.346	10348.2	276.9	10069.5	85.5	*****	528	1
133	1	5	4	VARY	0.198	4.916	7965.8	212.6	7751.1	87.2	*****	528	1
134	1	5	4	VARY	0.204	4.030	6318.7	178.0	6138.9	79.6	*****	528	1
135	1	5	4	VARY	0.198	2.936	4699.5	125.1	4573.2	76.3	*****	528	1
136	1	5	4	VARY	0.197	2.443	3920.3	103.2	3816.1	75.0	*****	528	1
137	1	5	4	VARY	0.203	1.588	3087.9	86.4	3000.7	74.2	*****	528	1
139	1	5	4	VARY	0.198	1.480	2293.8	61.3	2231.9	64.0	*****	601	1
140	1	5	4	VARY	0.197	1.239	1556.7	51.8	1904.4	69.4	*****	601	1
142	1	5	4	VARY	0.196	0.400	628.6	16.5	612.0	65.9	*****	601	1
143	1	5	4	VARY	0.197	0.455	782.9	20.8	762.0	70.6	*****	601	1
144	1	5	4	VARY	0.198	0.596	943.2	25.2	917.7	72.7	*****	601	1
145	1	5	4	VARY	0.199	0.701	1111.4	29.9	1081.3	74.5	*****	601	1
146	1	5	4	VARY	0.200	0.800	1267.0	34.5	1232.2	76.1	*****	601	1
147	1	5	4	VARY	0.202	0.912	1434.1	39.8	1393.8	77.8	*****	601	1
148	1	5	4	VARY	0.203	1.018	1598.4	44.8	1553.2	79.2	*****	601	1
150	1	5	4	VARY	0.031	1.052	10328.7	7.0	10321.7	67.9	*****	601	1
151	1	5	4	VARY	0.040	1.369	10328.3	11.7	10316.6	66.3	*****	601	1
152	1	5	4	VARY	0.060	2.048	10326.6	26.1	10300.5	65.4	*****	601	1
153	1	5	4	VARY	0.100	3.386	10326.1	71.5	10254.5	65.7	*****	601	1
154	1	5	4	VARY	0.120	4.054	10330.0	103.1	10226.5	66.8	*****	601	1
155	1	5	4	VARY	0.150	5.025	10326.4	160.7	10164.8	69.4	*****	601	1
156	1	5	4	VARY	0.179	5.909	10322.9	227.3	10093.7	73.6	*****	601	1
157	1	5	4	VARY	0.200	6.462	10328.4	281.3	10044.3	80.6	*****	601	1
158	3	42	41	0.00	0.204	6.048	VARY	274.1	VARY	90.0	0.060	602	2
159	1	47	41	16.4	0.205	6.014	VARY	274.6	VARY	91.6	VARY	602	2
160	1	51	41	20.0	0.204	5.949	VARY	272.5	VARY	93.3	VARY	602	2
161	1	60	41	35.2	0.204	6.048	VARY	278.7	VARY	96.4	VARY	602	2
162	1	47	41	15.0	0.205	6.006	VARY	277.9	VARY	97.1	VARY	VARY	7
163	1	41	41	25.0	0.204	6.068	VARY	280.0	VARY	97.2	VARY	602	2
164	2	28	41	-0.02	0.204	1.996	3142.5	88.6	3053.0	81.5	0.061	602	2
165	1	30	41	14.9	0.204	2.015	3184.7	90.3	3093.5	84.3	VARY	602	2
166	1	35	41	18.9	0.205	2.007	3150.5	90.2	3059.4	83.4	VARY	602	2

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MODEL: FAIR CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TO	CONF	ALPHA	MACHU	RN/FT	PT	QIU	PIU	TIF	PROBE	DATE	FMT
167	1	28	41	0.00	0.060	2.004	10470.6	26.3	10444.3	78.9	0.060	602	2
168	1	22	41	15.0	0.060	2.047	10469.0	26.6	10442.5	72.3	0.069	602	2
169	1	34	41	25.0	0.060	2.026	VARY	25.6	VARY	66.5	VARY	602	2
171	1	5	2	VARY	0.242	0.393	498.6	19.7	478.7	60.8	*****	602	1
172	1	5	2	VARY	0.247	0.481	606.3	24.9	581.0	66.1	*****	603	1
173	1	5	2	VARY	0.247	0.592	753.7	30.7	722.5	69.2	*****	602	1
174	1	5	2	VARY	0.244	0.685	884.1	35.5	848.1	71.3	*****	602	1
175	1	5	2	VARY	0.247	0.785	1008.8	41.1	967.1	72.8	*****	603	1
176	1	5	2	VARY	0.245	0.879	1141.1	46.0	1094.5	74.4	*****	603	1
177	1	5	2	VARY	0.244	0.879	1277.5	51.2	1225.5	75.7	*****	602	1
178	1	5	2	VARY	0.246	1.227	1600.6	65.0	1534.6	78.6	*****	603	1
179	1	5	2	VARY	0.246	1.472	1933.8	78.5	1854.1	81.2	*****	603	1
181	1	5	2	VARY	0.246	1.576	2527.5	102.9	2423.1	70.5	*****	604	1
182	1	5	2	VARY	0.246	2.483	3278.8	133.2	3143.5	83.6	*****	604	1
183	1	5	2	VARY	0.246	2.577	VARY	163.0	VARY	91.9	*****	604	1
184	1	5	2	VARY	0.250	4.002	5293.6	222.3	5067.8	91.5	*****	604	1
185	1	5	2	VARY	0.249	1.990	2587.0	107.3	2478.1	81.4	*****	604	1
186	1	5	2	VARY	0.248	2.505	3332.4	137.1	3193.1	89.6	*****	604	1
188	1	5	2	VARY	0.239	0.405	521.8	20.1	501.4	62.0	*****	604	1
189	1	5	2	VARY	0.243	0.490	629.9	25.0	604.5	67.7	*****	604	1
190	1	5	2	VARY	0.246	0.590	756.5	30.6	725.4	70.5	*****	604	1
191	1	2	2	20.0	0.246	0.605	775.9	31.5	743.9	71.3	*****	604	1
192	1	5	2	VARY	0.246	0.622	800.3	32.5	767.4	72.5	*****	604	1
193	1	5	2	VARY	0.246	0.694	895.5	36.4	858.6	74.1	*****	604	1
194	1	5	2	VARY	0.246	0.793	1027.2	41.7	984.9	75.7	*****	604	1
195	1	5	2	VARY	0.247	0.889	1151.4	47.1	1103.6	76.8	*****	604	1
196	1	5	2	VARY	0.246	0.987	1286.0	52.3	1232.8	78.2	*****	604	1
198	1	5	2	VARY	0.245	1.220	1556.7	62.9	1492.8	68.1	*****	607	1
199	1	5	2	VARY	0.247	1.475	1902.0	77.7	1823.1	74.7	*****	607	1
200	1	5	2	VARY	0.246	1.599	2673.9	108.9	2563.3	89.6	*****	607	1
201	1	5	2	VARY	0.247	2.476	3336.8	126.4	3198.3	93.7	*****	607	1
202	1	5	2	VARY	0.248	2.594	4020.1	165.8	3851.7	94.1	*****	607	1
203	1	5	2	VARY	0.248	3.957	5362.8	221.3	5138.0	98.3	*****	607	1

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MODEL: FAR CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEC FROM	SEC TO	CONF	ALPHA	MACHU	RN/FT	PT	QIU	PIU	TIF	PROBE	DATE	FMT
204	1	5	2	VARY	0.248	4.553	6790.1	279.5	6506.3	102.8	****	607	1
205	1	5	2	VARY	0.249	5.563	8278.2	340.9	7882.1	107.1	****	607	1
206	1	5	2	VARY	0.248	6.751	9408.5	387.9	9014.7	110.6	****	607	1
209	1	5	2	VARY	0.113	2.781	VARY	68.3	VARY	78.3	****	607	1
209	1	5	2	VARY	0.036	0.909	VARY	7.2	VARY	76.9	****	607	1
210	1	5	2	VARY	0.046	1.150	7792.1	11.4	7780.7	75.5	****	607	1
211	1	5	2	VARY	VARY	VARY	VARY	VARY	VARY	75.3	****	607	1
212	1	5	2	VARY	0.115	2.872	7794.7	72.0	7722.5	76.8	****	607	1
213	1	5	2	VARY	VARY	VARY	VARY	VARY	VARY	78.8	****	607	1
214	1	5	2	VARY	0.173	4.243	7818.2	160.4	7656.6	81.3	****	607	1
215	1	5	2	VARY	0.207	5.015	7839.0	227.8	7608.7	84.8	****	607	1
216	2	20	2	0.04	0.246	VARY	VARY	VARY	VARY	VARY	****	607	2
217	3	18	21	0.04	0.247	1.968	2557.7	104.8	2451.3	78.7	0.015	608	2
218	1	12	21	15.1	0.247	1.946	2573.9	105.2	2467.2	85.6	0.016	608	2
219	1	10	21	25.1	0.248	1.940	2583.0	106.4	2475.0	90.1	0.017	608	2
220	1	16	21	0.04	0.248	3.570	5363.8	221.0	5139.4	96.6	0.032	608	2
221	1	18	21	15.1	0.247	3.949	VARY	220.8	VARY	99.1	0.041	608	2
222	1	24	21	25.1	0.248	3.913	5335.4	220.3	5111.7	101.1	0.073	609	2
223	1	17	21	0.04	VARY	VARY	VARY	VARY	VARY	101.3	0.035	608	2
224	1	16	21	15.1	0.248	5.893	8116.9	334.5	7777.3	105.2	0.042	608	2
226	1	5	3	VARY	0.246	0.419	537.7	21.8	515.5	71.7	****	609	1
227	1	5	3	VARY	0.247	0.487	629.9	25.9	603.6	76.9	****	609	1
228	1	5	3	VARY	0.249	0.594	768.8	32.0	736.3	80.0	****	609	1
229	1	5	3	VARY	0.251	0.695	899.2	37.8	860.8	82.3	****	609	1
230	1	5	3	VARY	0.249	0.798	1040.8	43.3	996.9	83.0	****	609	1
231	1	5	3	VARY	0.248	0.890	1167.3	48.0	1118.5	83.1	****	609	1
232	1	5	3	VARY	0.248	0.989	1296.3	53.5	1242.0	83.7	****	609	1
233	1	5	3	VARY	0.247	1.230	1620.5	66.6	1552.9	85.0	****	609	1
234	1	5	3	VARY	0.247	1.474	1950.1	79.7	1869.2	85.8	****	609	1
235	1	5	3	VARY	VARY	VARY	VARY	VARY	VARY	87.0	****	609	1
236	1	5	3	VARY	0.247	1.581	2629.3	108.0	2519.7	88.2	****	609	1
237	1	5	3	VARY	0.247	2.485	3322.9	135.8	3185.1	90.3	****	609	1
238	1	5	3	VARY	0.248	2.975	3984.8	164.2	3818.1	92.7	****	609	1

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MODEL: FAR CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TO	CONF	ALPHA	MACHU	RA/FT	PT	QIU	PIU	TTF	PROBE	DATE	FMT
239	1	5	3	VARY	0.247	3.462	4678.6	191.0	4484.7	94.7	****	609	1
240	1	5	3	VARY	0.247	3.562	5379.3	270.1	5155.9	97.2	****	609	1
241	1	5	3	VARY	0.247	4.509	6733.9	275.2	6454.5	101.5	****	609	1
242	1	5	3	VARY	0.247	5.895	8166.7	334.3	7827.3	106.3	****	609	1
243	1	5	3	VARY	0.248	7.028	9852.1	405.0	9440.9	112.6	****	609	1
244	2	5	3	VARY	0.203	5.770	9699.5	270.8	9425.9	108.1	****	609	1
245	1	1	3	0.63	0.181	5.217	9664.8	217.7	9445.4	102.2	****	609	1
246	1	1	3	0.65	0.151	4.394	9664.8	151.3	9512.7	99.8	****	609	1
247	1	1	3	0.64	0.123	3.539	9399.6	98.4	9300.9	94.4	****	609	1
248	1	1	3	0.64	0.103	2.562	9350.1	68.4	9281.5	92.0	****	609	1
249	1	1	3	0.65	0.072	2.073	9325.4	33.4	9291.9	91.1	****	609	1
250	1	1	3	0.65	0.062	1.806	9294.9	25.3	9269.6	89.6	****	609	1
251	1	1	3	0.63	0.040	1.164	9264.5	10.5	9254.1	88.4	****	609	1
252	1	1	3	0.53	0.031	0.886	9229.9	6.0	9223.8	87.0	****	609	1
253	1	1	3	0.53	0.041	1.172	9202.3	10.6	9191.7	85.8	****	609	1
254	1	1	3	0.53	0.063	1.811	9195.9	25.2	9170.7	85.4	****	609	1
255	1	1	3	0.53	0.072	2.089	9190.3	33.5	9156.7	85.1	****	609	1
256	1	1	3	0.53	0.103	2.971	9187.4	67.8	9119.5	84.9	****	609	1
257	1	1	3	0.53	0.124	3.567	9189.6	97.9	9091.3	85.0	****	609	1
258	1	1	3	0.53	0.155	4.433	9203.7	151.7	9051.1	85.8	****	609	1
259	1	1	3	0.53	0.187	5.379	9232.0	220.6	9009.5	87.4	****	609	1
260	1	1	3	0.53	0.206	5.856	9264.5	268.4	8993.3	89.4	****	609	1
261	1	1	3	0.53	0.029	0.206	2123.2	1.2	2122.0	54.9	****	609	1
262	1	1	3	0.53	0.041	0.295	2118.3	2.5	2115.8	56.5	****	609	1
263	1	1	3	0.53	0.060	0.421	2118.3	5.3	2113.0	61.3	****	609	1
264	1	3	3	0.53	0.100	0.700	2118.3	VARY	2103.0	64.7	****	609	1
265	1	1	3	0.53	0.145	1.023	2117.6	32.3	2085.1	68.0	****	609	1
266	1	1	3	0.53	0.181	1.230	2117.6	47.3	2069.9	70.4	****	609	1
267	1	1	3	0.53	0.200	1.352	2117.6	57.6	2059.4	71.7	****	609	1
268	1	25	31	0.04	VARY	0.387	VARY	VARY	VARY	72.0	0.032	610	2
269	1	22	31	10.0	0.245	0.410	533.2	21.5	511.3	75.7	0.031	610	2
270	1	33	31	25.1	VARY	0.406	VARY	VARY	VARY	78.3	0.073	610	2
271	1	24	31	16.9	VARY	0.412	VARY	VARY	VARY	80.3	0.047	610	2

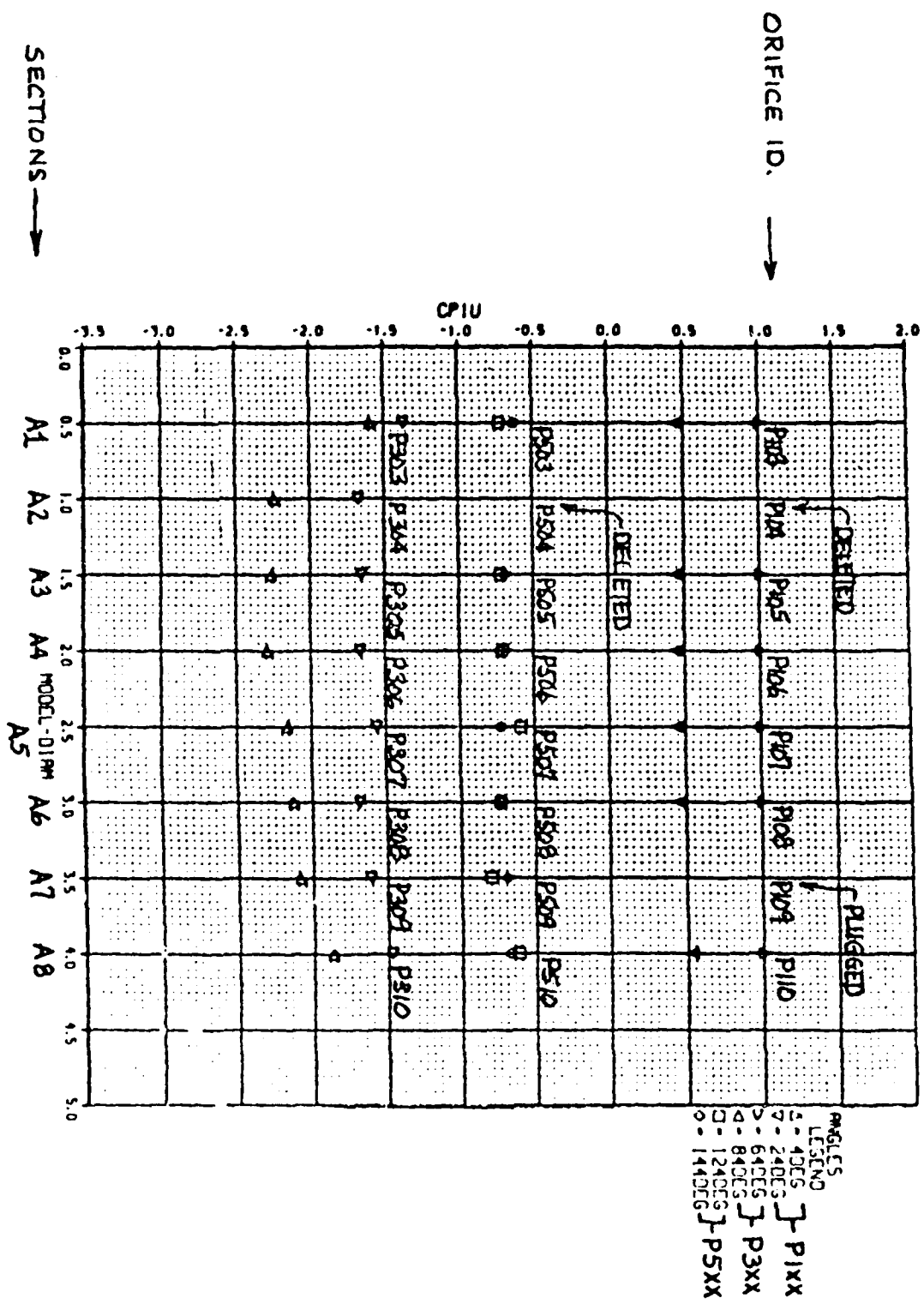
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MODEL: FAR CYLINDER TABLE IV - RUN SCHEDULE (AVERAGE VALUES FOR A RUN)

RUN	SEQ FROM	SEQ TC	CONF	ALPHA	MACHU	RN/FT	PT	Q1U	P1U	TTF	PROBE	DATE	FMT
272	1	21	31	0.06	0.248	0.493	642.2	26.5	615.3	81.3	0.038	610	2
273	1	23	31	10.0	0.248	0.503	654.0	27.0	626.6	80.1	0.045	610	2
274	1	22	31	25.1	VARY	0.492	VARY	VARY	VARY	79.3	0.075	610	2
275	1	20	31	0.06	0.249	0.789	1020.7	42.6	977.4	80.4	0.033	610	2
276	1	21	31	15.0	VARY	0.763	VARY	VARY	VARY	79.5	0.053	610	2
277	1	30	31	25.1	0.250	0.819	VARY	44.1	VARY	78.8	VARY	610	2
278	1	20	31	15.0	0.247	2.955	3893.7	159.8	3731.4	84.8	0.043	610	2
279	1	35	31	25.1	VARY	VARY	VARY	VARY	VARY	86.9	VARY	610	2
280	1	46	31	20.0	0.247	2.861	VARY	VARY	VARY	88.6	0.059	610	2
281	1	27	31	20.0	0.248	1.618	2117.6	87.6	2028.7	83.5	0.059	610	2
282	1	35	31	25.1	0.248	1.613	2117.1	87.6	2028.2	84.7	VARY	610	2
283	9	31	31	15.0	0.248	6.807	9361.8	384.8	8971.1	104.0	0.052	611	2
284	1	30	31	25.1	0.248	6.749	9364.7	385.4	8973.4	108.2	VARY	611	2
285	1	24	31	20.0	0.248	6.687	9342.1	384.2	8951.9	111.1	0.069	611	2
286	1	30	31	10.1	0.248	6.617	VARY	393.4	VARY	113.8	0.051	611	2
287	1	27	31	15.0	0.248	5.912	8290.5	341.0	7944.3	112.8	0.046	611	2
288	1	41	31	25.1	0.248	5.875	VARY	339.4	VARY	112.9	VARY	611	2
289	1	31	31	20.0	0.248	5.835	VARY	337.8	VARY	113.0	0.059	611	2
290	1	25	31	20.0	0.248	4.920	6856.6	283.1	6569.1	110.0	0.061	611	2
291	1	28	31	25.1	0.247	4.885	6813.3	279.6	6529.5	109.9	VARY	611	2
292	1	25	31	15.0	0.247	4.852	6766.3	277.3	6484.8	109.5	0.049	611	2
293	1	25	31	15.0	0.247	3.918	VARY	222.1	VARY	105.5	0.043	611	2
294	1	29	31	25.1	0.249	3.898	VARY	221.0	VARY	105.2	VARY	611	2
295	1	25	31	23.1	0.247	3.870	VARY	218.8	VARY	104.3	0.073	611	2
296	1	25	31	20.0	0.248	3.860	5294.0	218.7	5072.0	103.7	0.061	611	2
297	1	23	31	23.1	0.248	2.945	4001.3	165.0	3833.7	99.2	VARY	611	2
298	1	30	31	25.1	0.247	2.439	3308.4	135.1	3171.2	96.4	VARY	611	2
299	1	23	31	20.0	0.247	2.423	3275.0	134.3	3138.6	95.7	0.057	611	2
300	1	24	31	20.0	0.248	1.958	2622.5	107.9	2513.0	92.3	0.056	611	2
301	1	30	31	25.1	0.248	1.948	2604.8	107.1	2496.0	91.6	VARY	611	2
302	1	25	31	20.0	0.249	1.001	VARY	54.5	1256.0	84.7	0.052	611	2
303	1	23	31	25.1	0.248	1.032	1353.0	56.0	1296.1	84.6	VARY	611	2

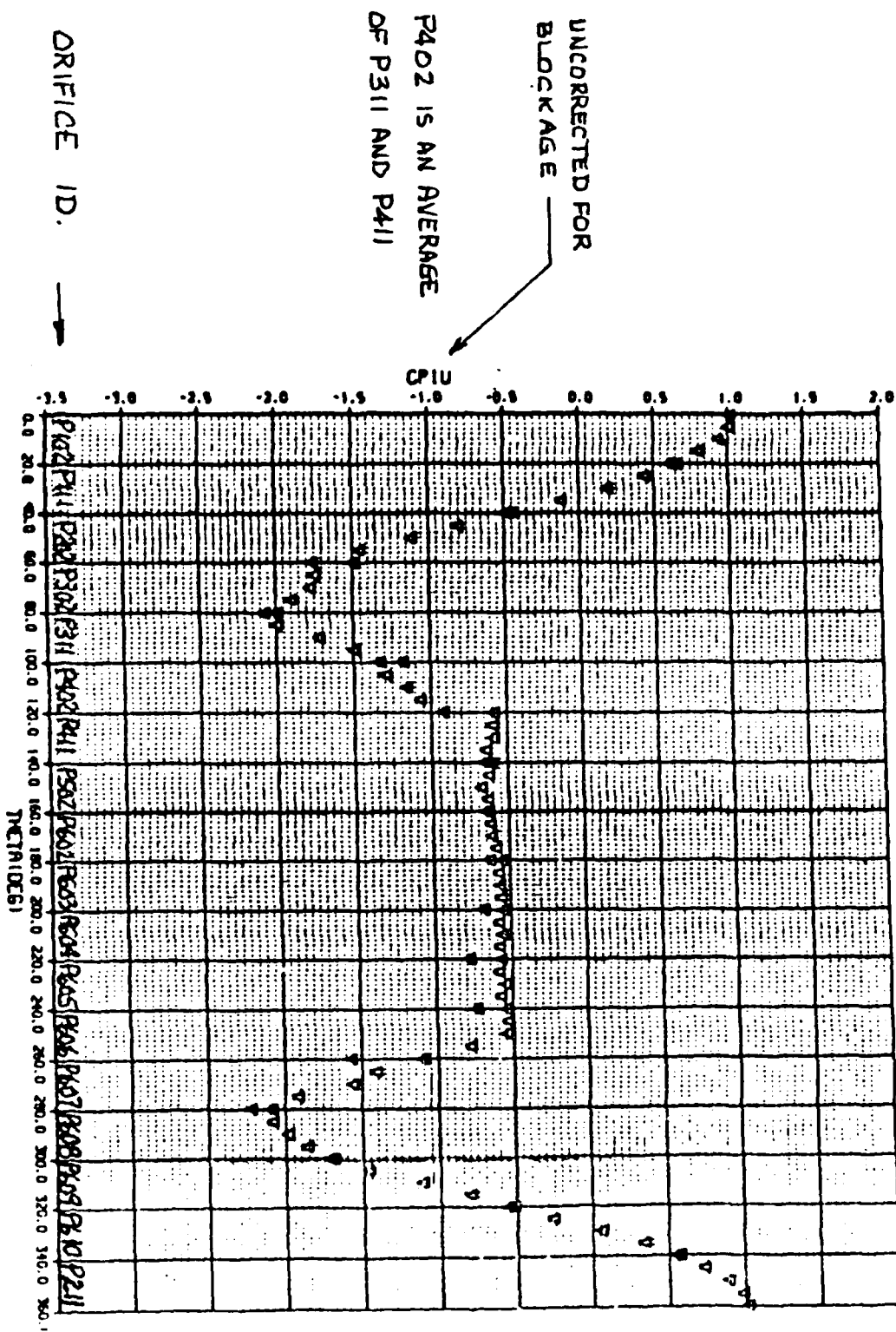


TEST, PHASE, TUN, RUN, SEQ.  
 226, 1, 12 5.00 5.00 LONGITUDINAL PRESSURE COEFFICIENTS

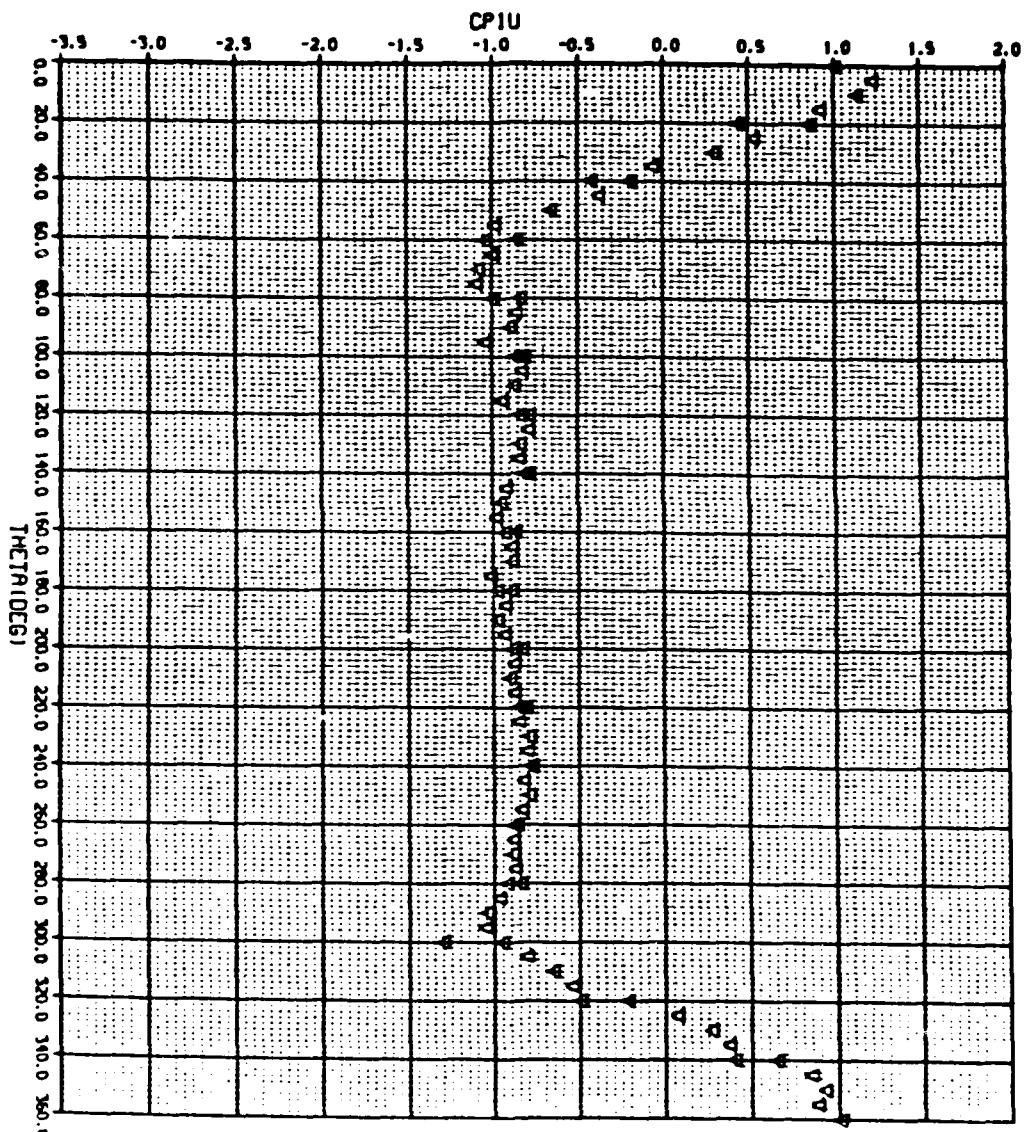


TEST PHASE TUN. RUN SEG.  
226.1.12 5.00: 5.00 DMC PRESS. COEFFICIENTS

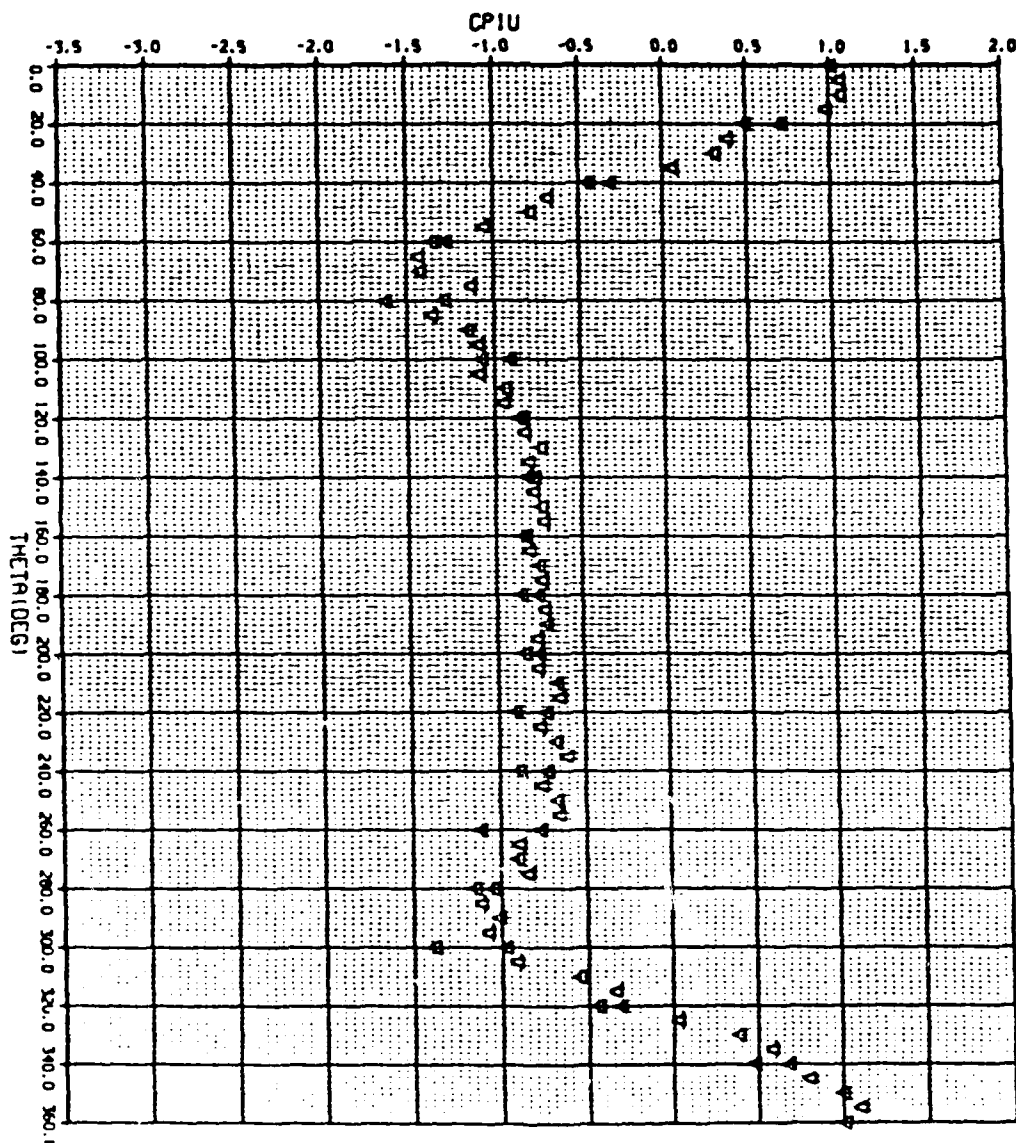
INTEGRATED SECTION COEFF.  
0.0518 CO- 0.4930 INC-7.653  
FROM SEG. 5



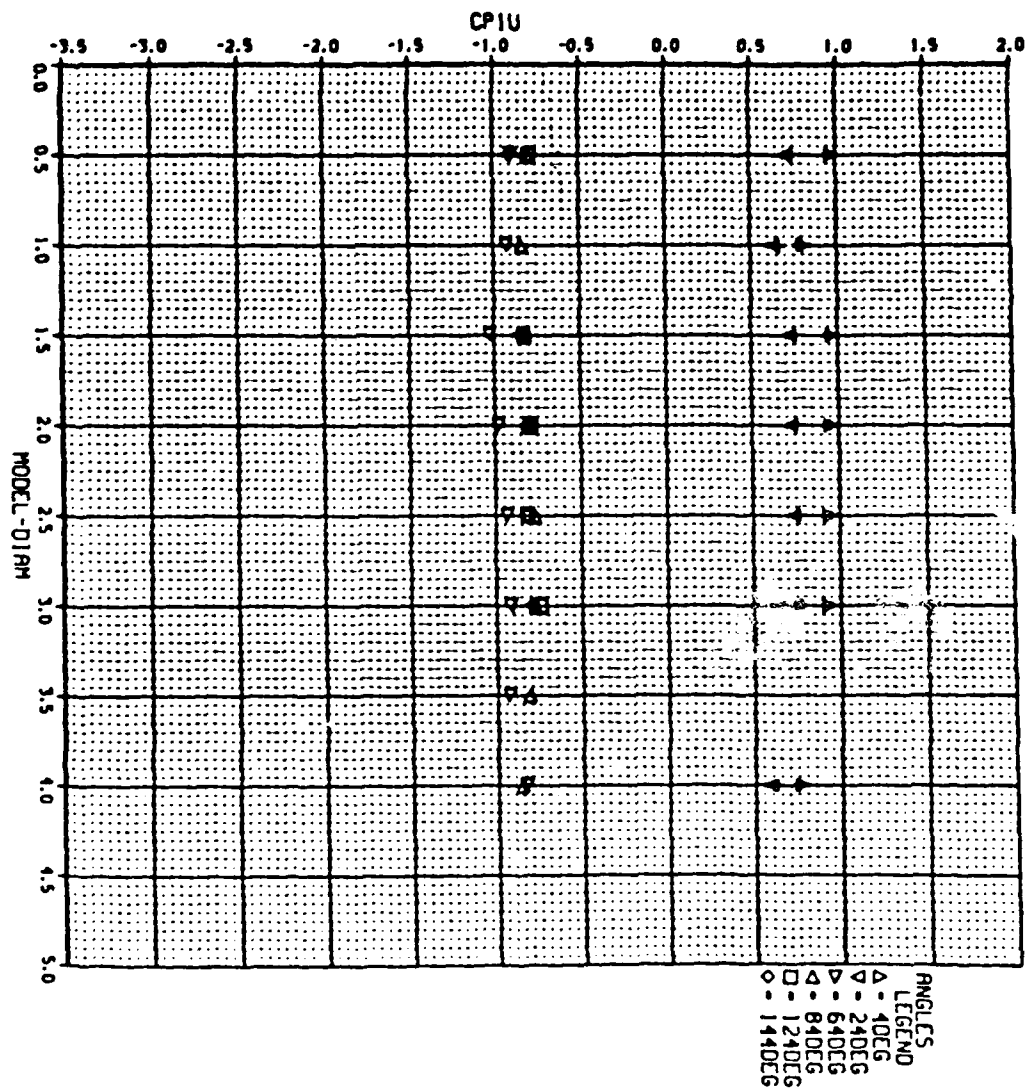
226.1,12 33.00: 5.00 QMC PRESS. COEFFICIENTS CL- 0.0117 CD- 0.9994 RND-0.306



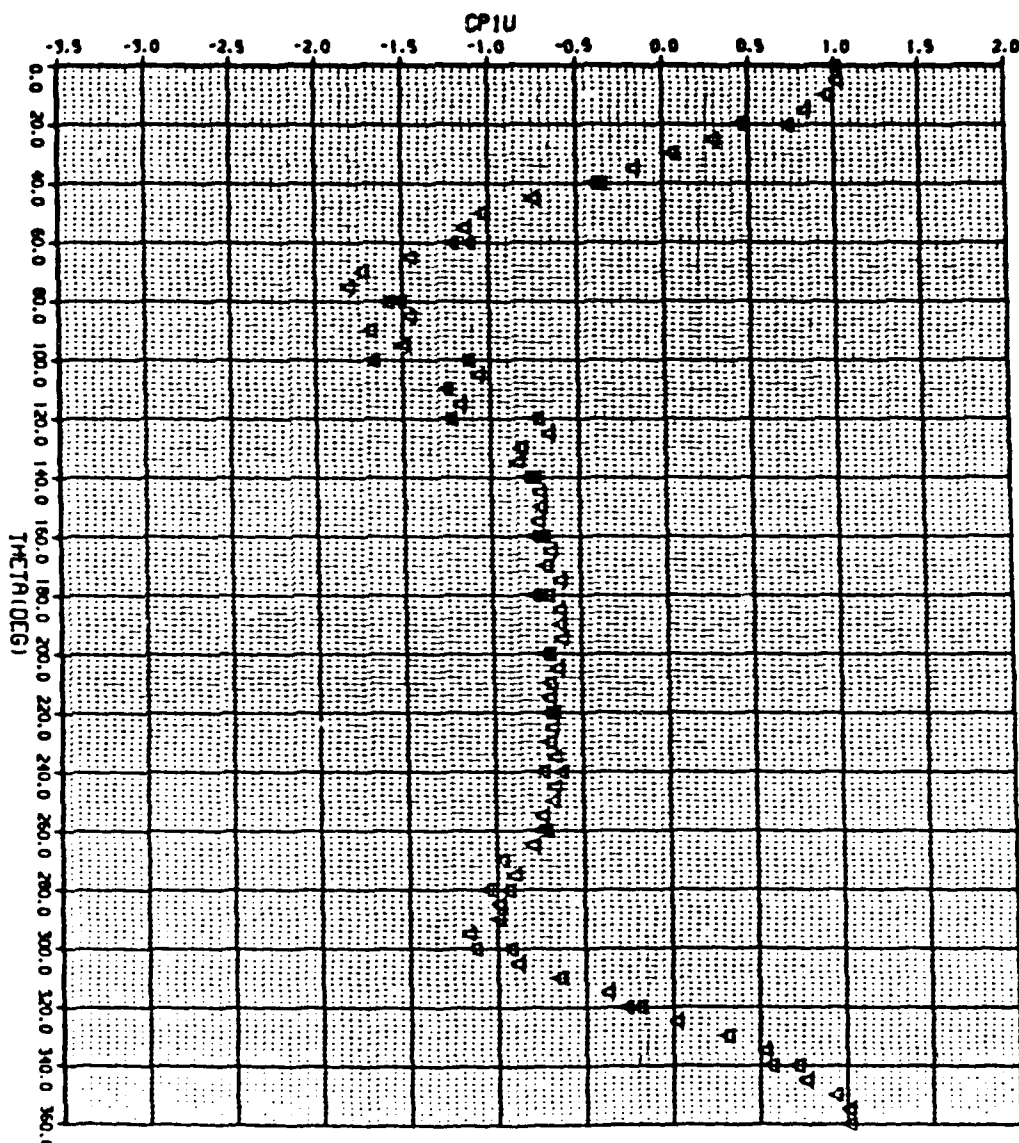
226,1.12 38.00: 5.00 QUNC PRESS. COEFFICIENTS CL- 0.1787 CD- 0.8525 RND-0.389



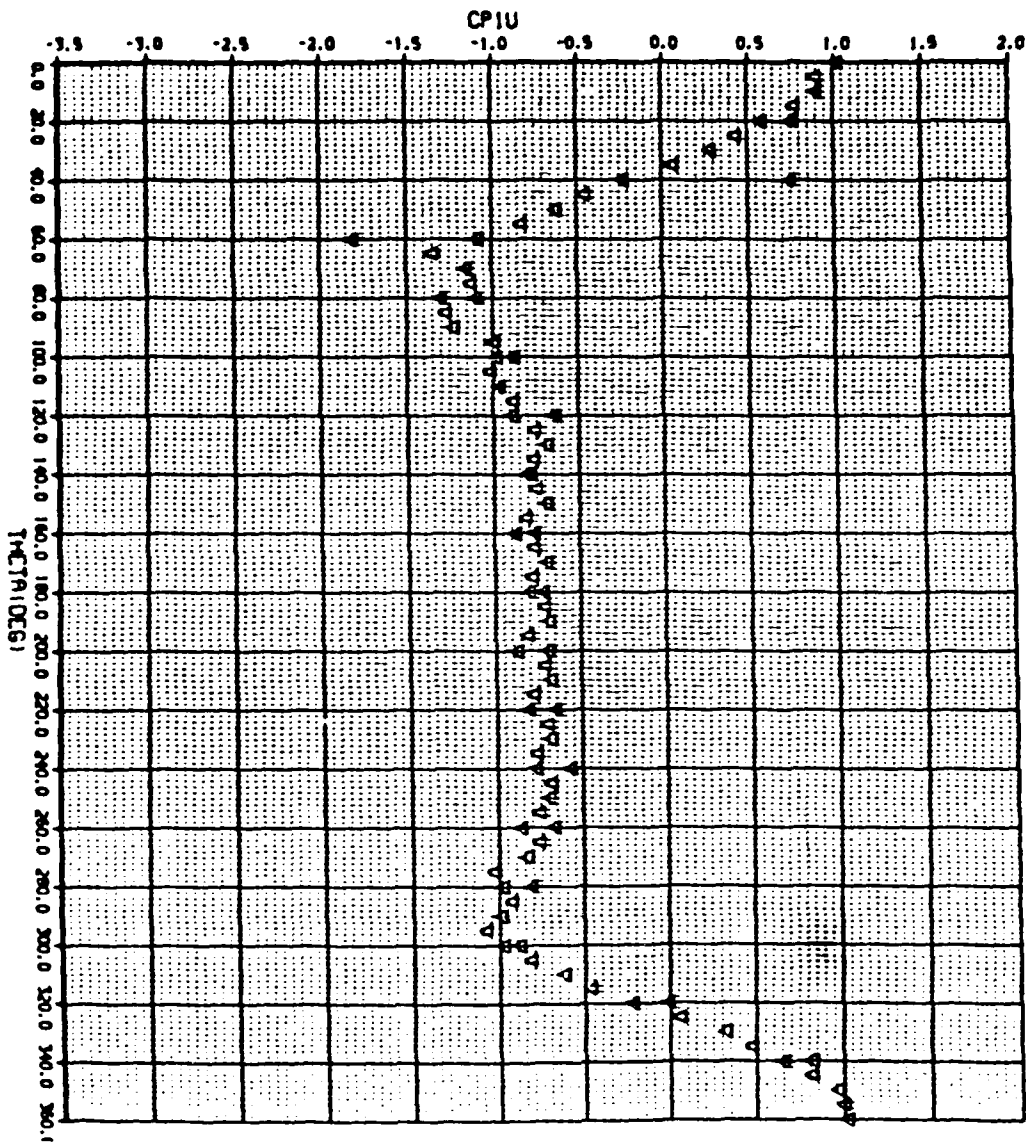
226.1,12 33.001 5.00 LONGITUDINAL PRESSURE COEFFICIENTS



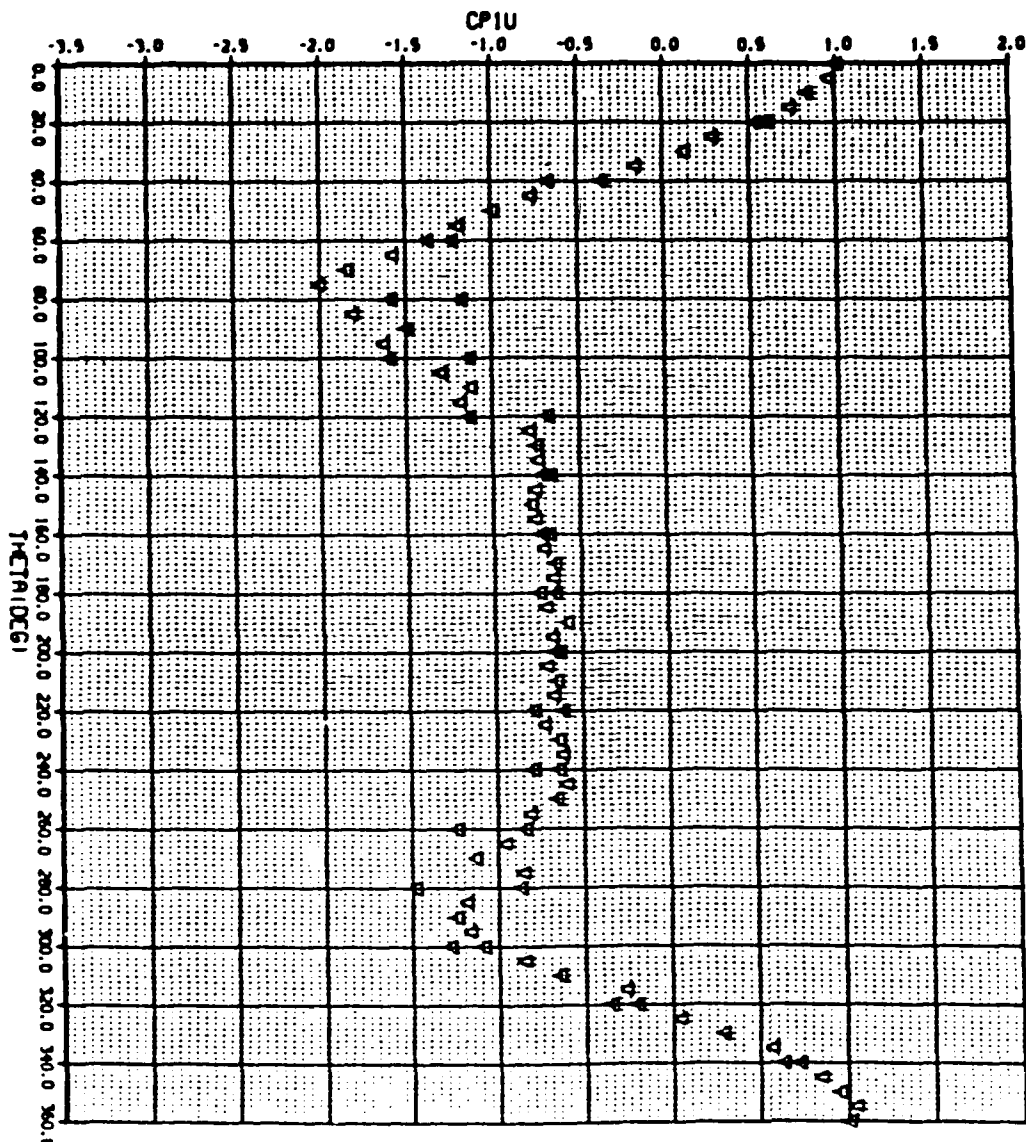
226.1.12 39.00: 5.00 DUNC PRESS. COEFFICIENTS CL- 0.3610 CD- 0.7471 RND-0.402



226.1,12 21.001 5.00 QMC PRESS. COEFFICIENTS CL- 0.1350 CO- 0.8713 RND-0.408

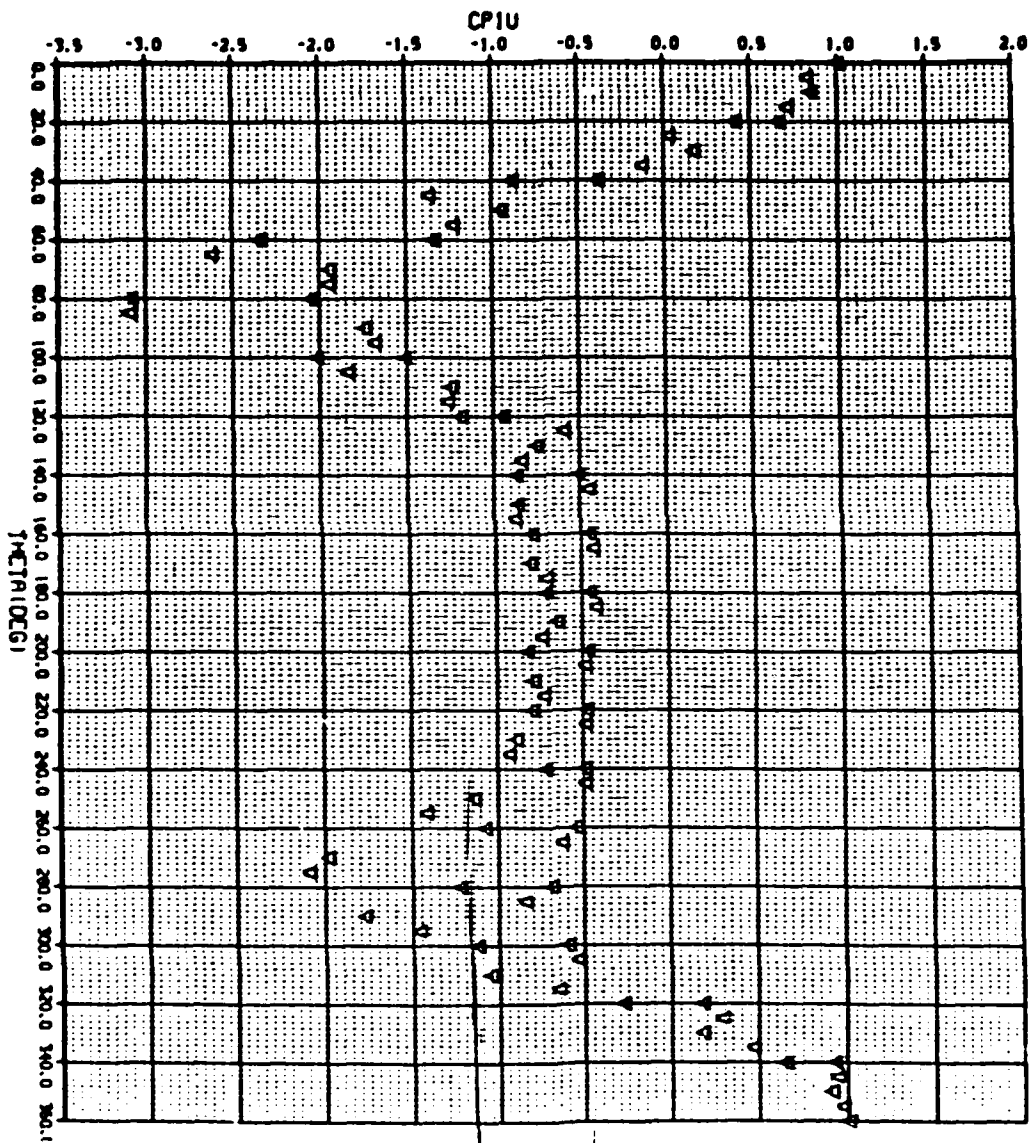


226,1,12 40.00 5.00 QMC PRESS. COEFFICIENTS CL- 0.3435 CO- 0.7291 RND-0.411

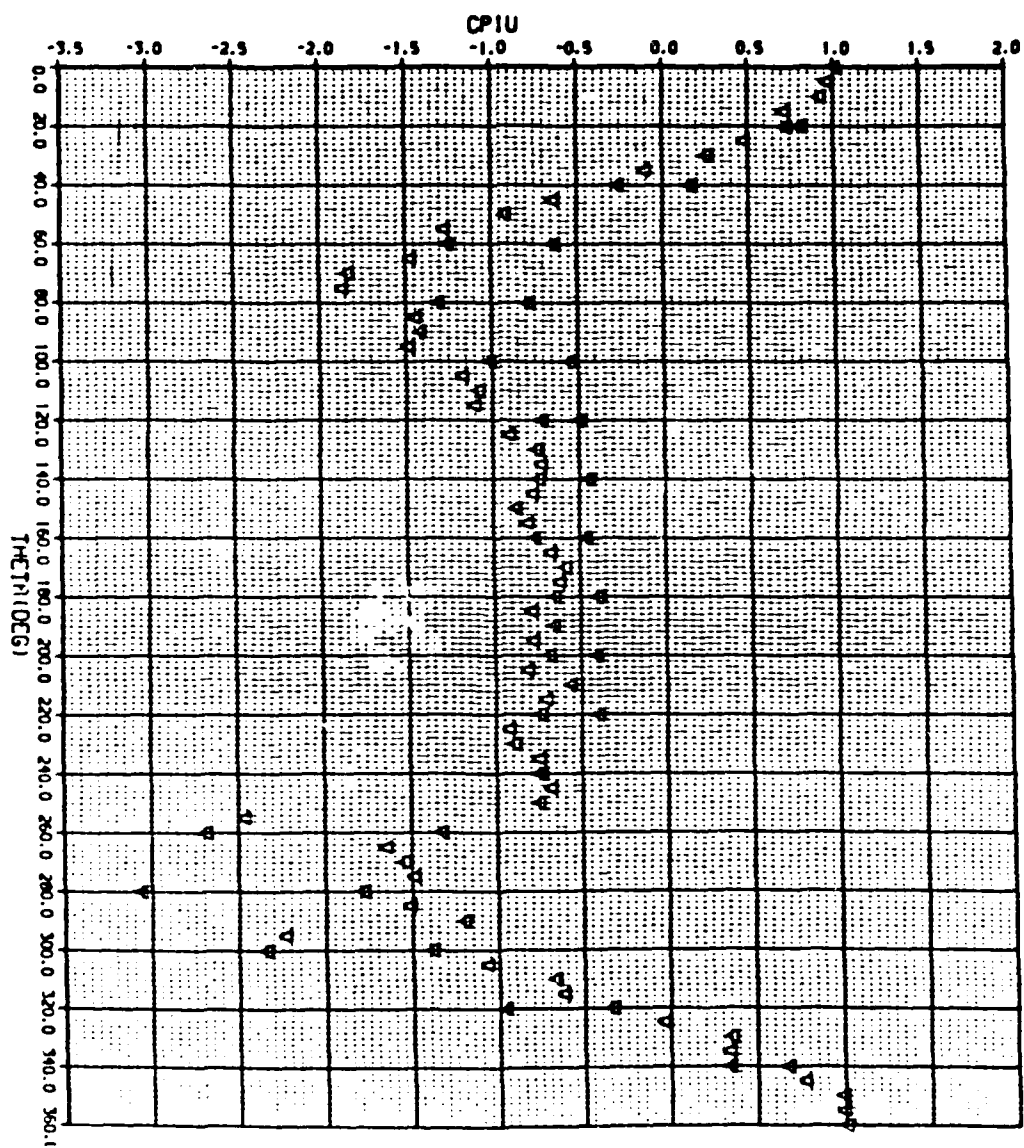




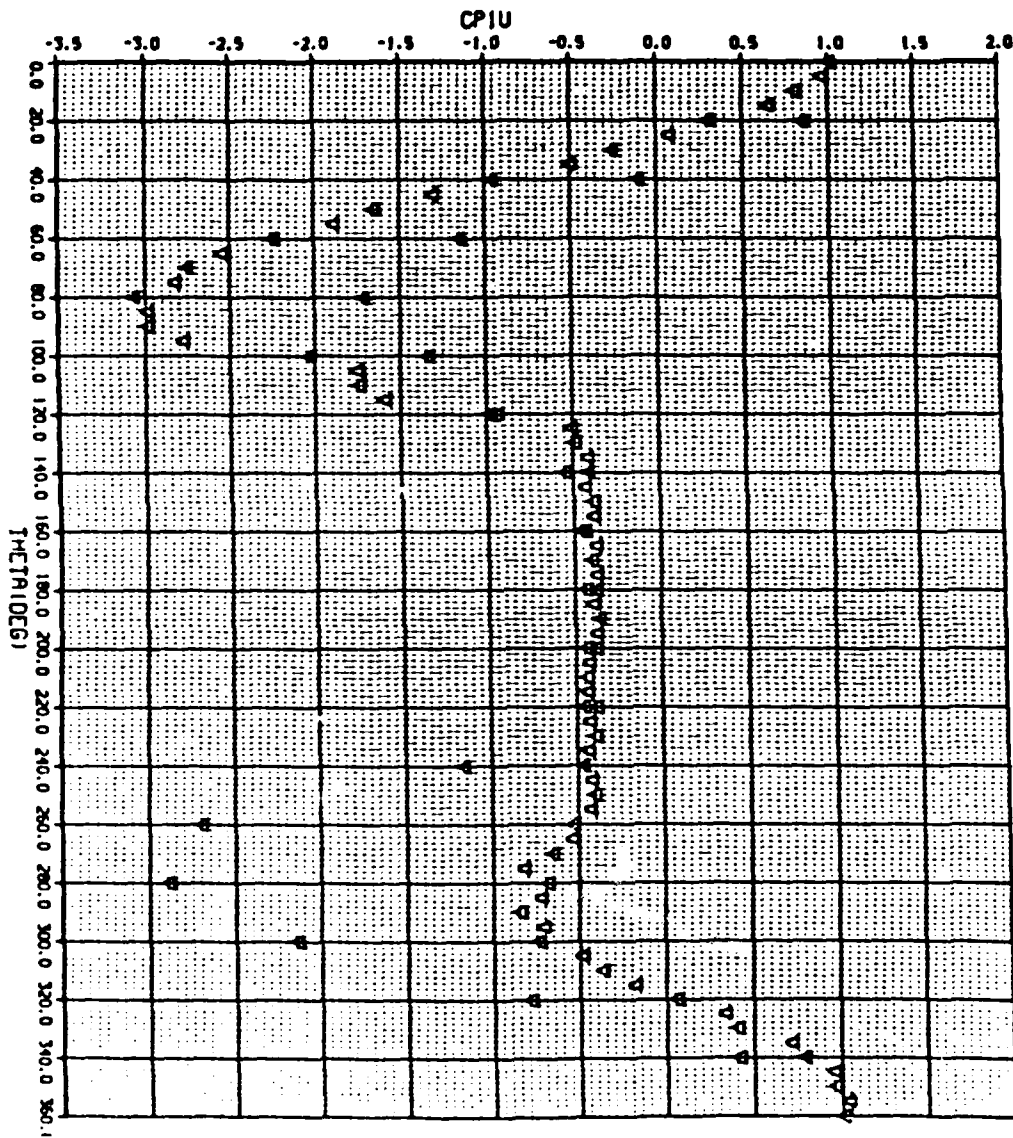
226,1,12 45.00: 5.00 QMC PRESS. COEFFICIENTS CL- 0.4760 CD- 0.6473 RND-0.422



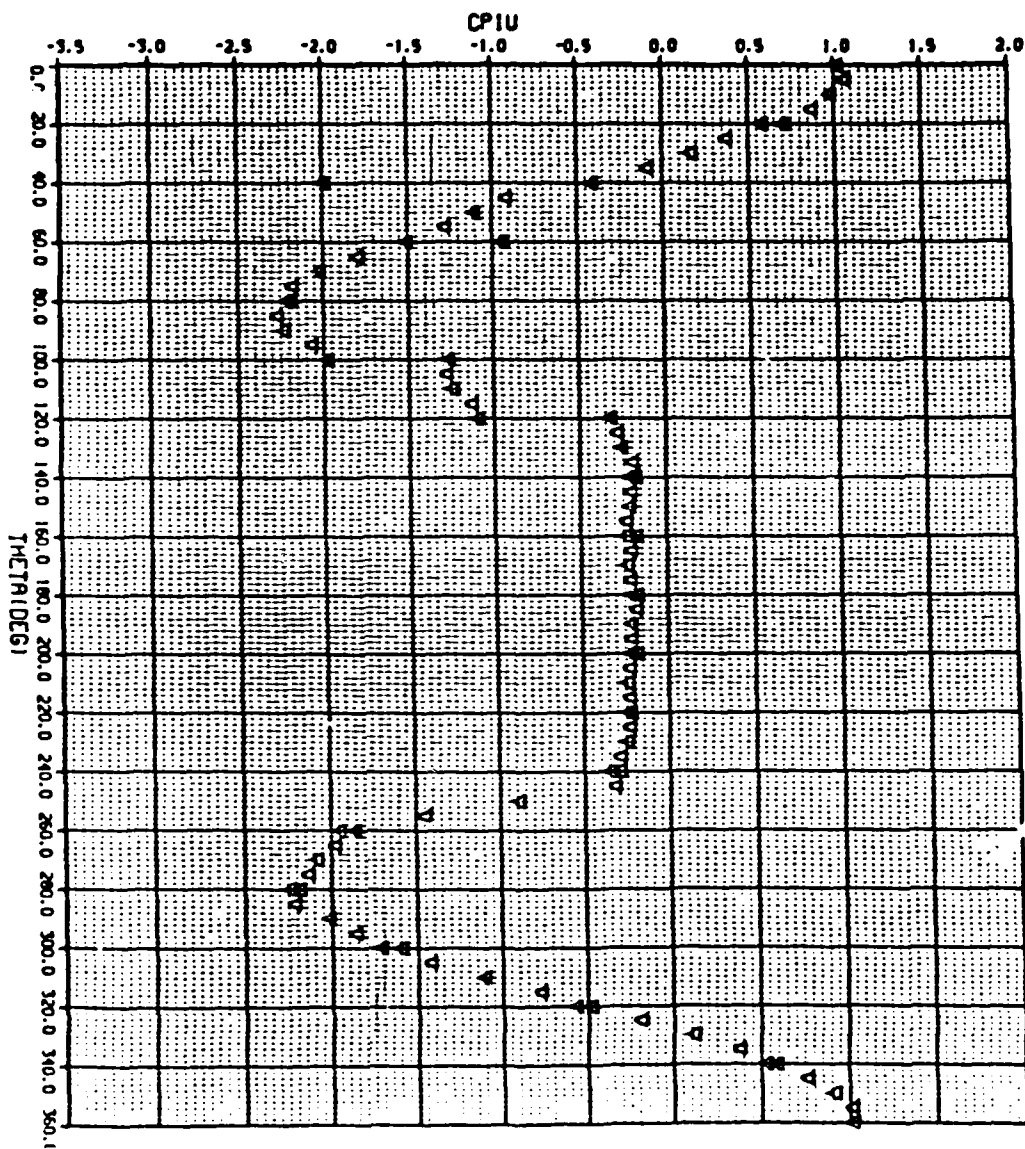
226,1,12 42.00 5.00 DMC PRESS. COEFFICIENTS CL--0.1810 CO- 0.7215 RND-0.426



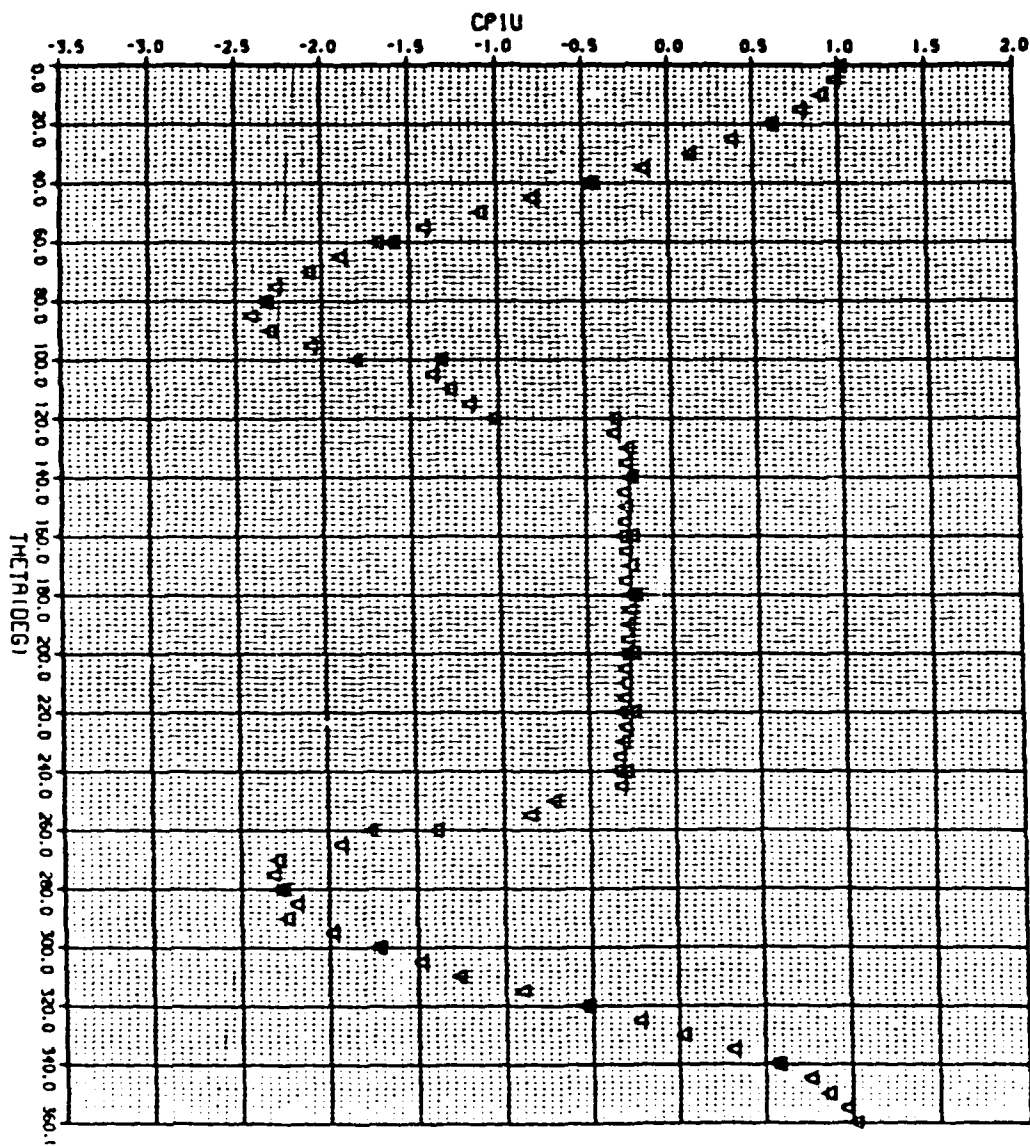
226.1, 12 43.00: 5.00 QMC PRESS. COEFFICIENTS CL- 0.9230 CD- 0.4224 RND-0.433



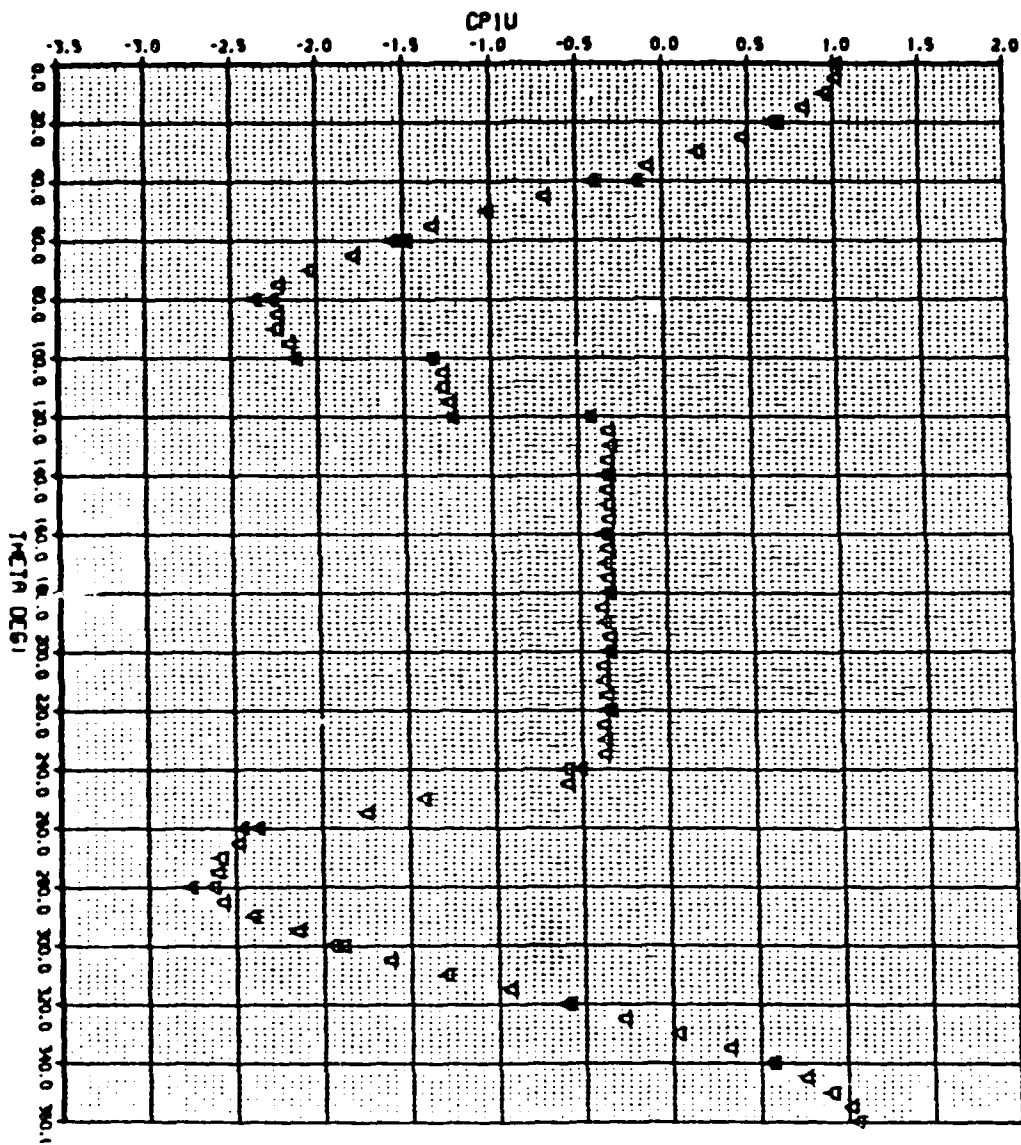
226.1,12 22.001 5.00 QAC PRESS. COEFFICIENTS CL- 0.0510 CD- 0.1755 RND-0.509



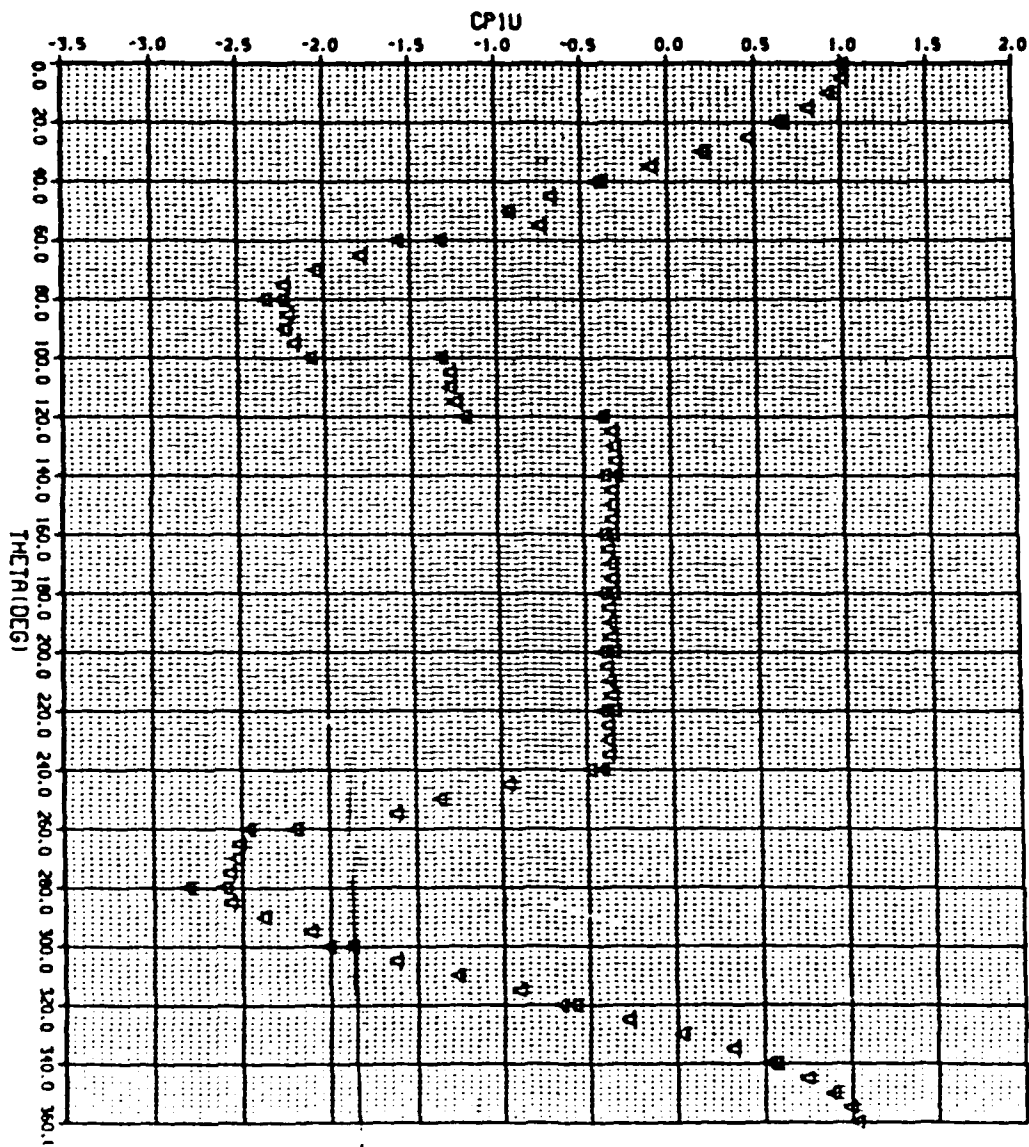
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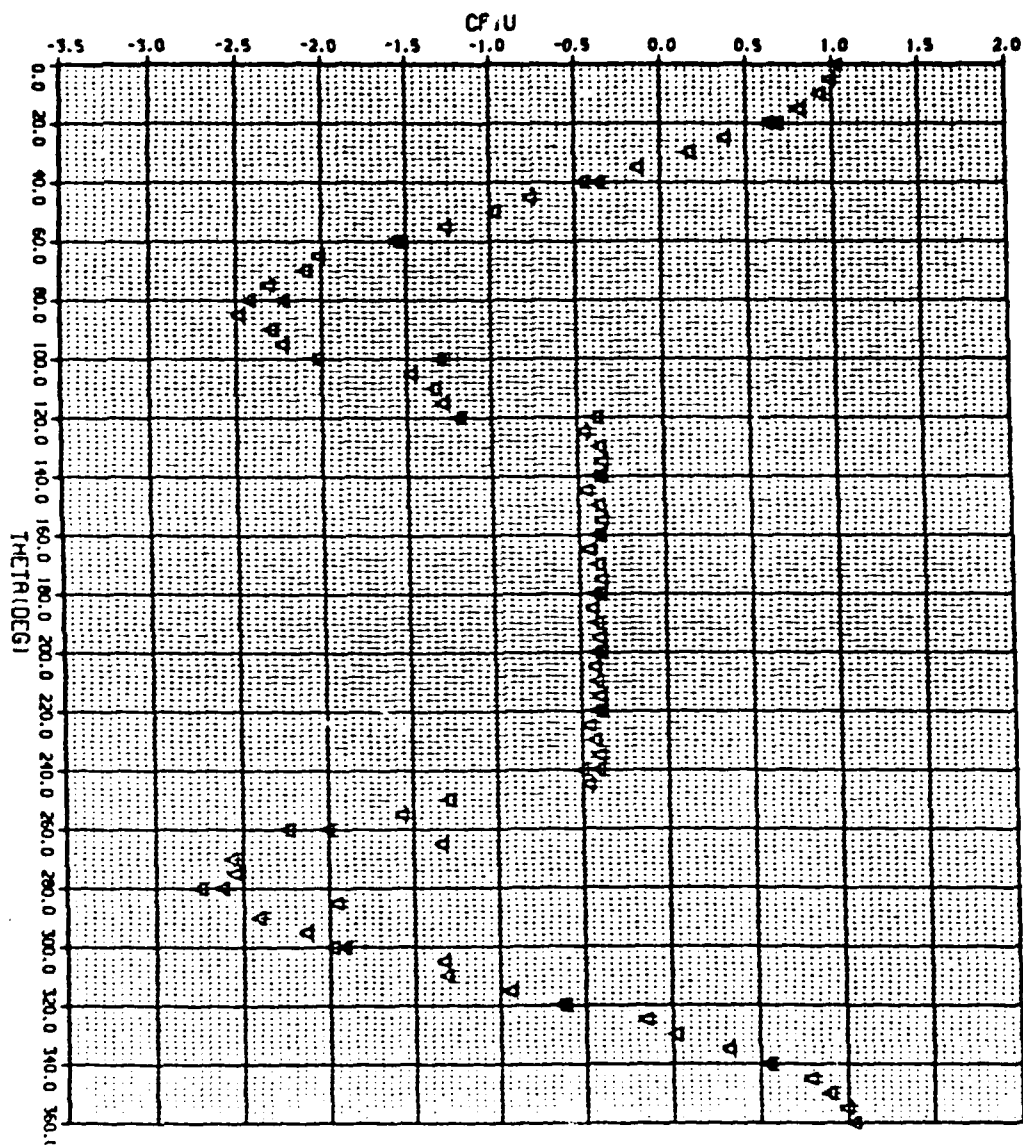
226,1,12 16.00: 5.00 QMC PRESS. COEFFICIENTS CL--0.1956 CO- 0.2943 RND-1.266



226,1,12 15.00: 5.00 QAC PRESS. COEFFICIENTS CL=-0.2180 CD- 0.3115 RND-1.512

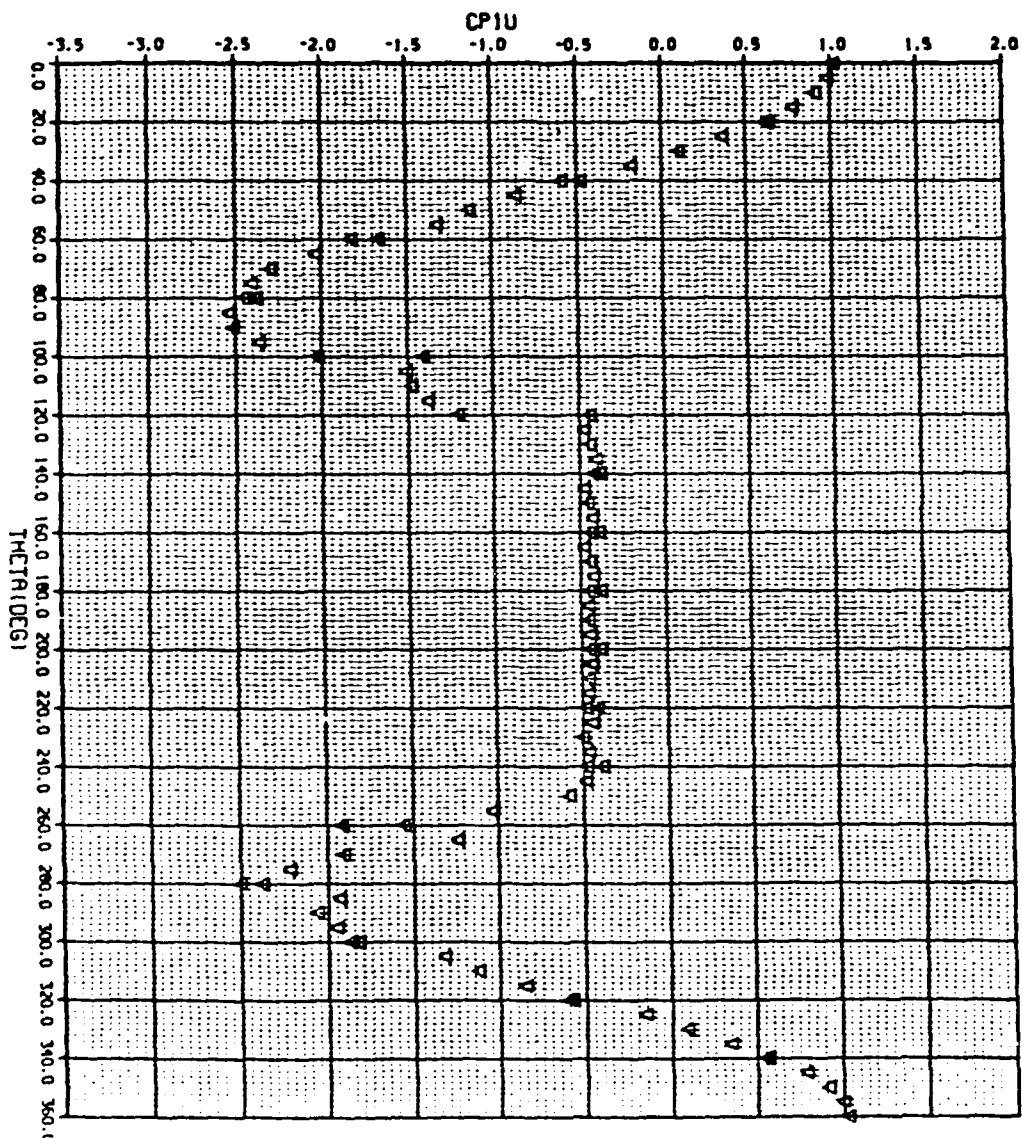


226,1,12 14.00: 5.00 QUNC PRESS. COEFFICIENTS CL=-0.0205 CD=0.3221 RND=1.085

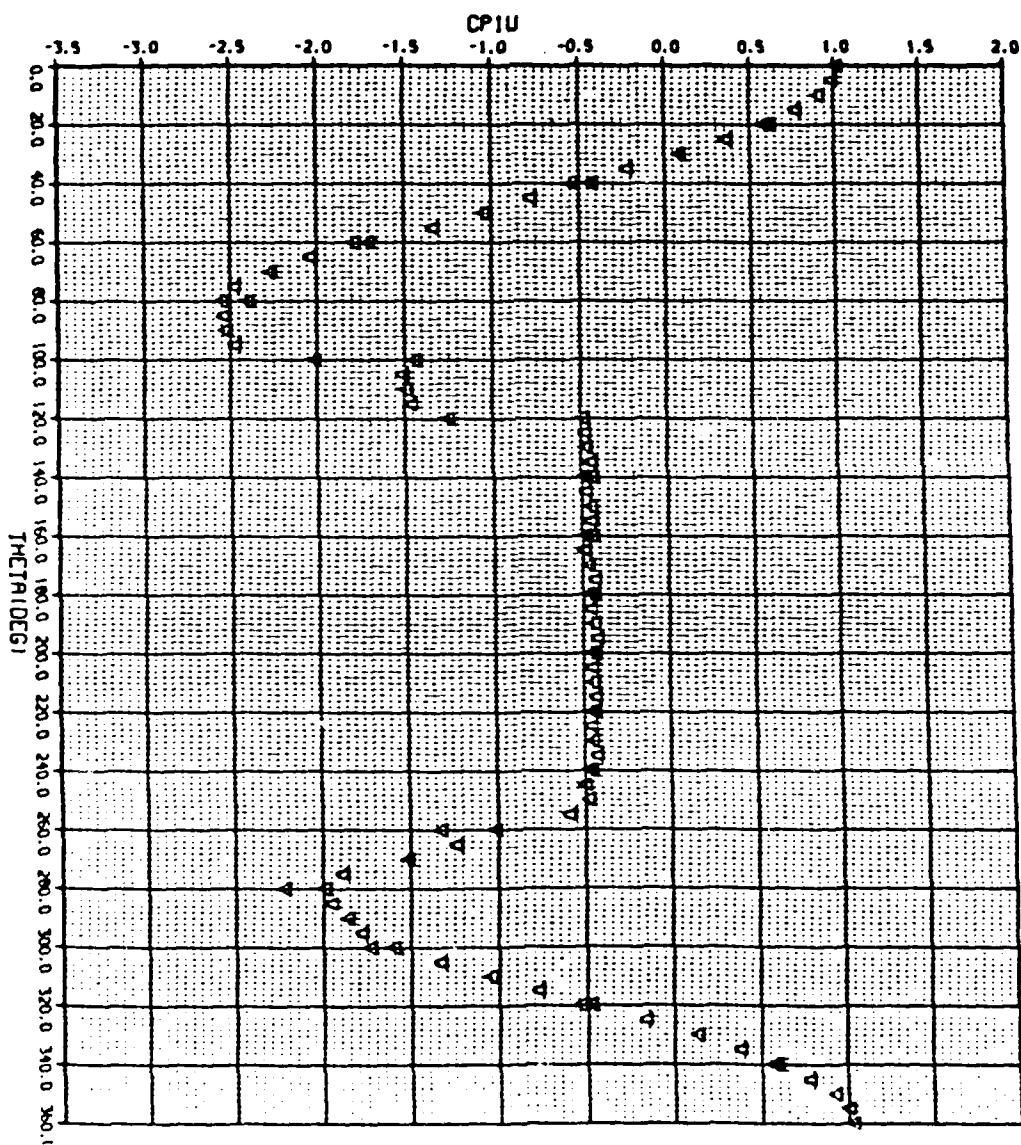




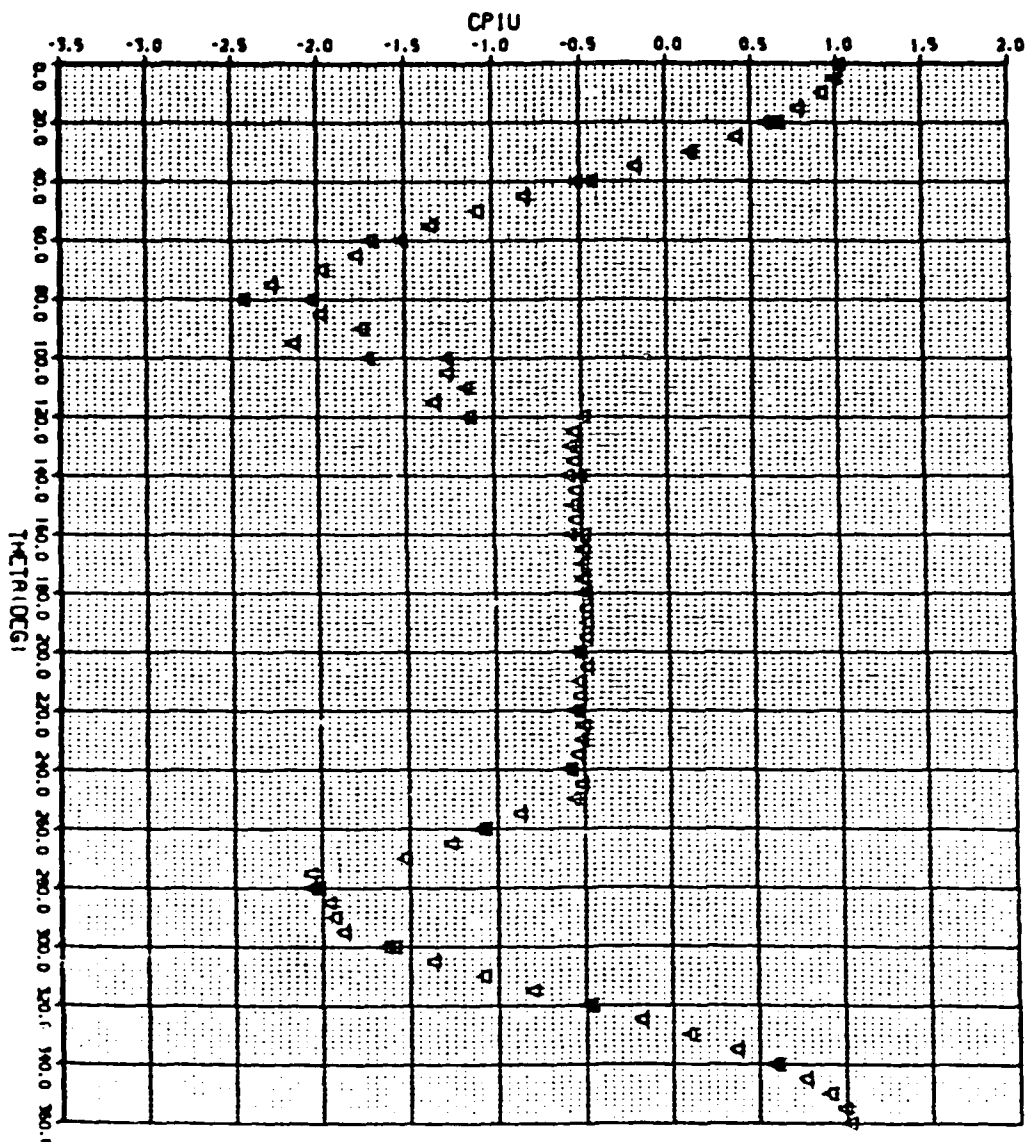
226,1,12 13.001 5.00 QMC PRESS. COEFFICIENTS CL- 0.2163 CD- 0.3428 RND-2.520



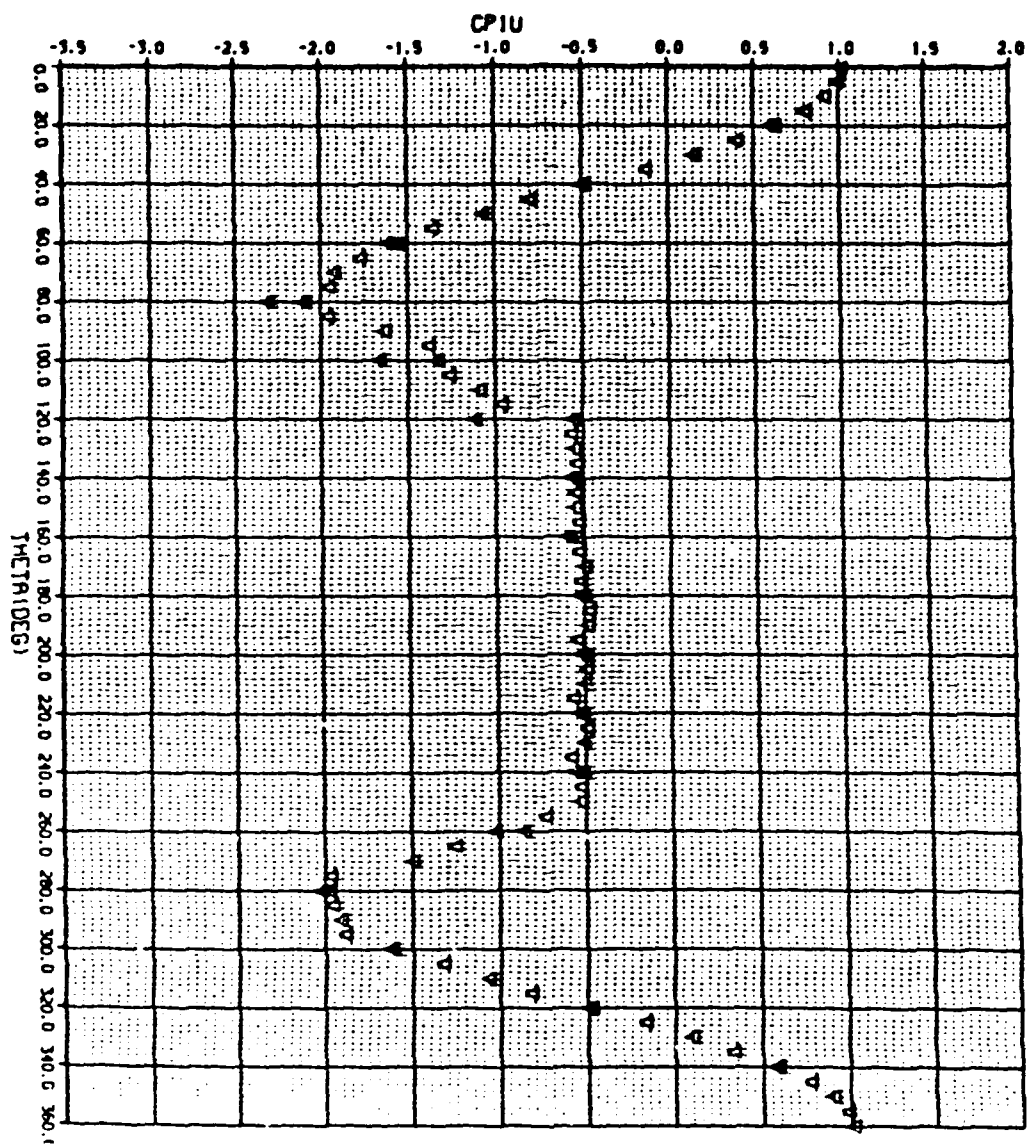
226,1,12 12.00: 5.00 QMC PRESS. COEFFICIENTS CL- 0.3584 CO- 0.3668 RND-2.971



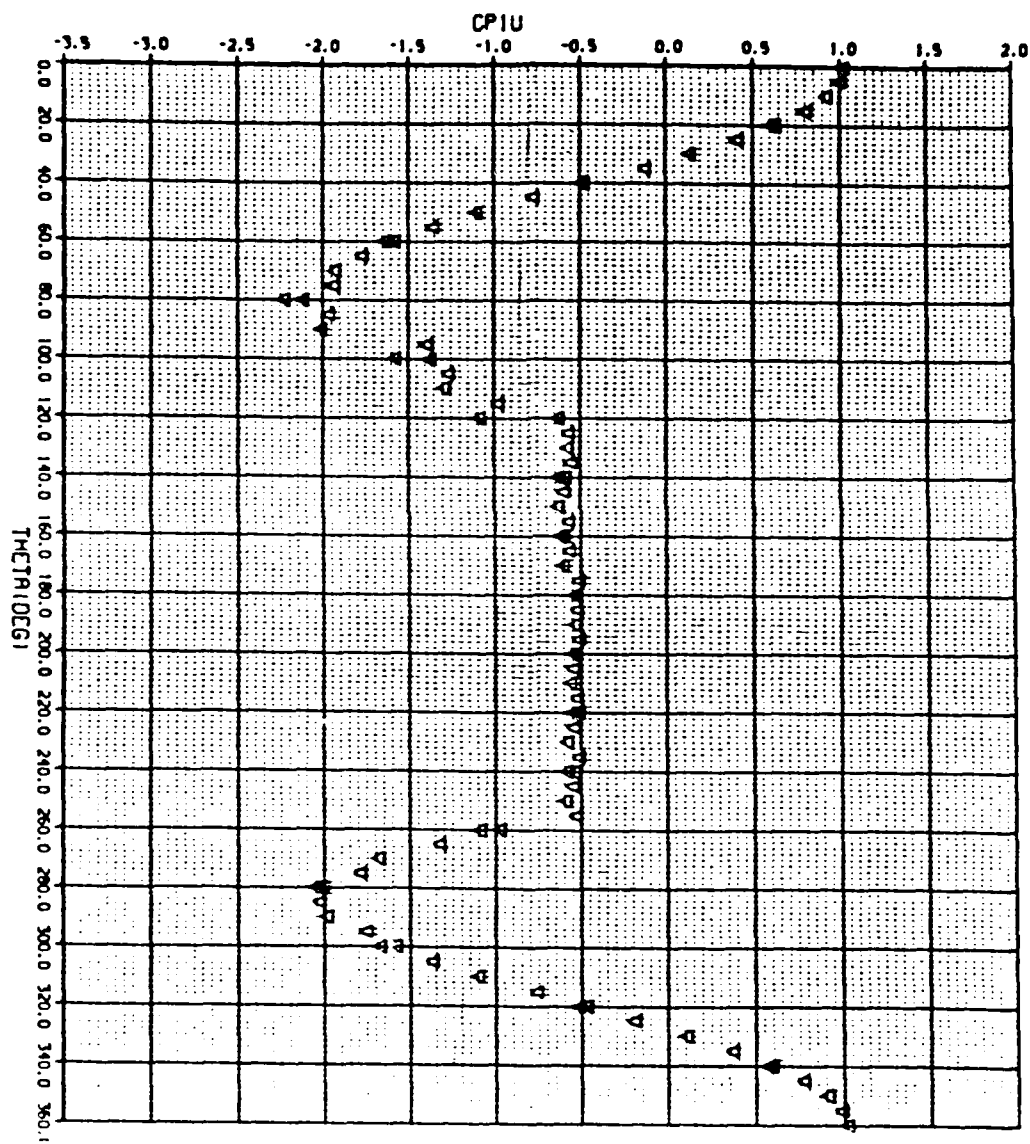
226,1,12 9.00: 5.00 DMC PRESS. COEFFICIENTS CL- 0.1644 CD- 0.4300 RND-3.926



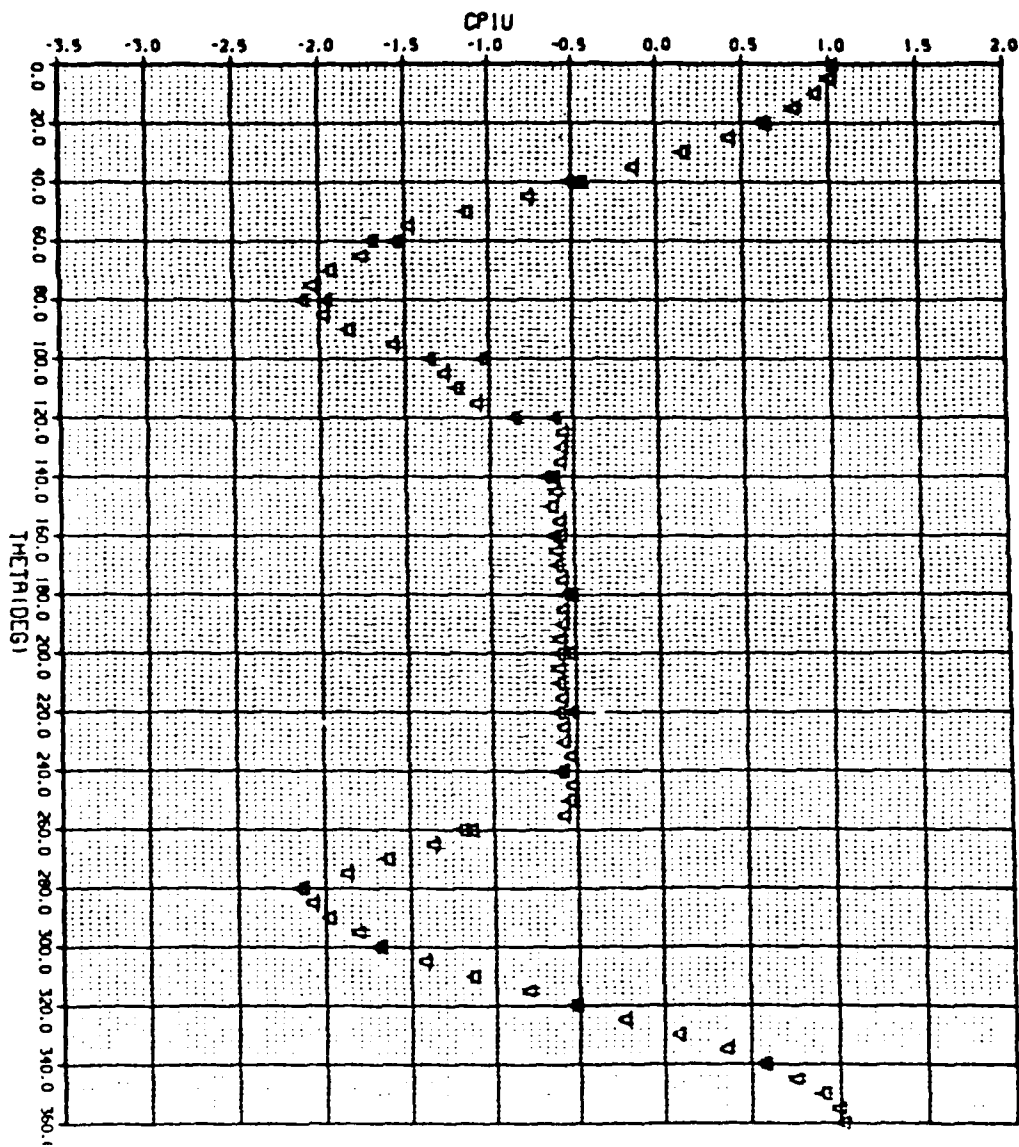
226.1,12 8.001 5.00 DUNC PRESS. COEFFICIENTS CL- 0.1136 CD- 0.4310 RND-4.919



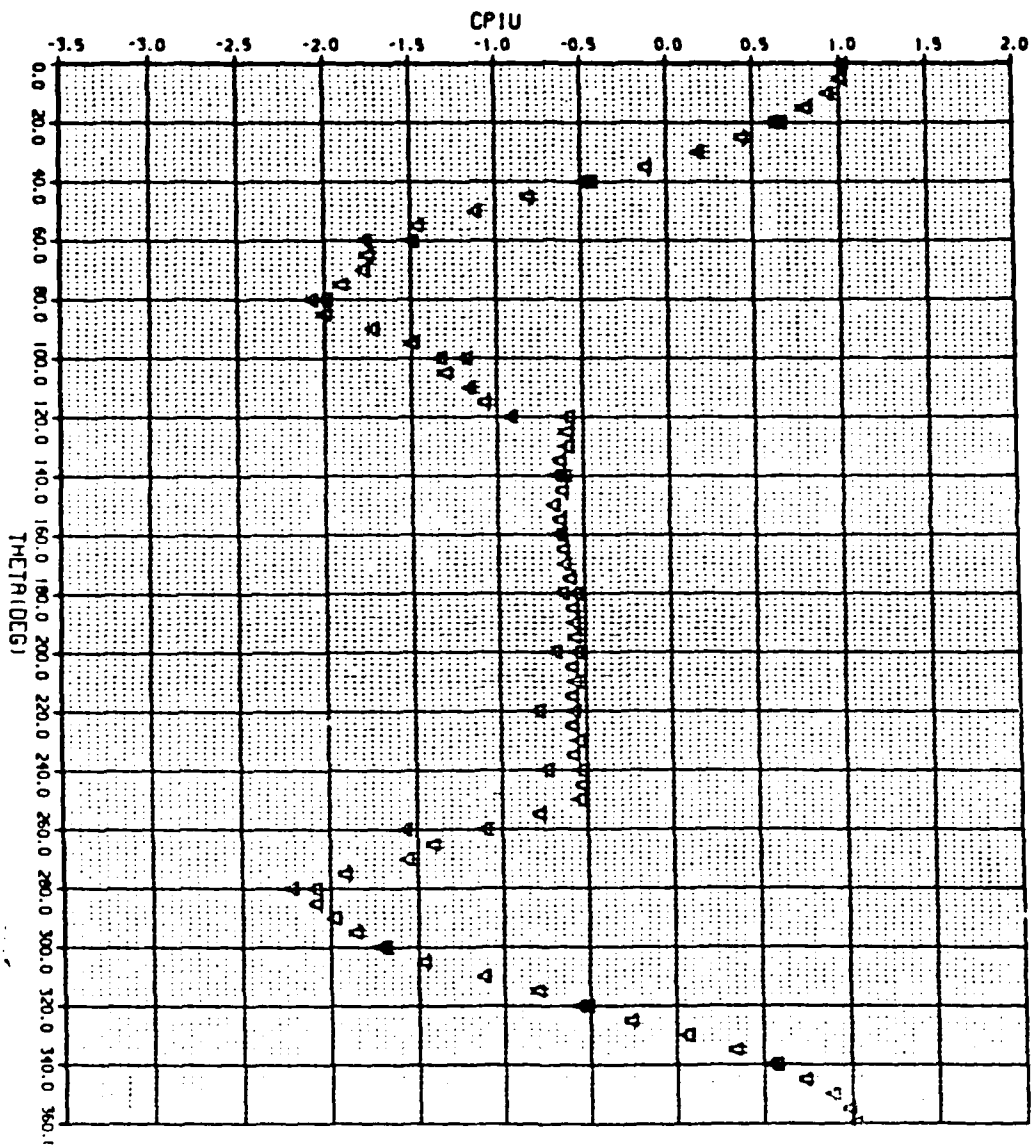
226.1,12 7.001 5.00 QUNC PRESS. COEFFICIENTS CL- 0.1371 CD- 0.4633 RND-5.873



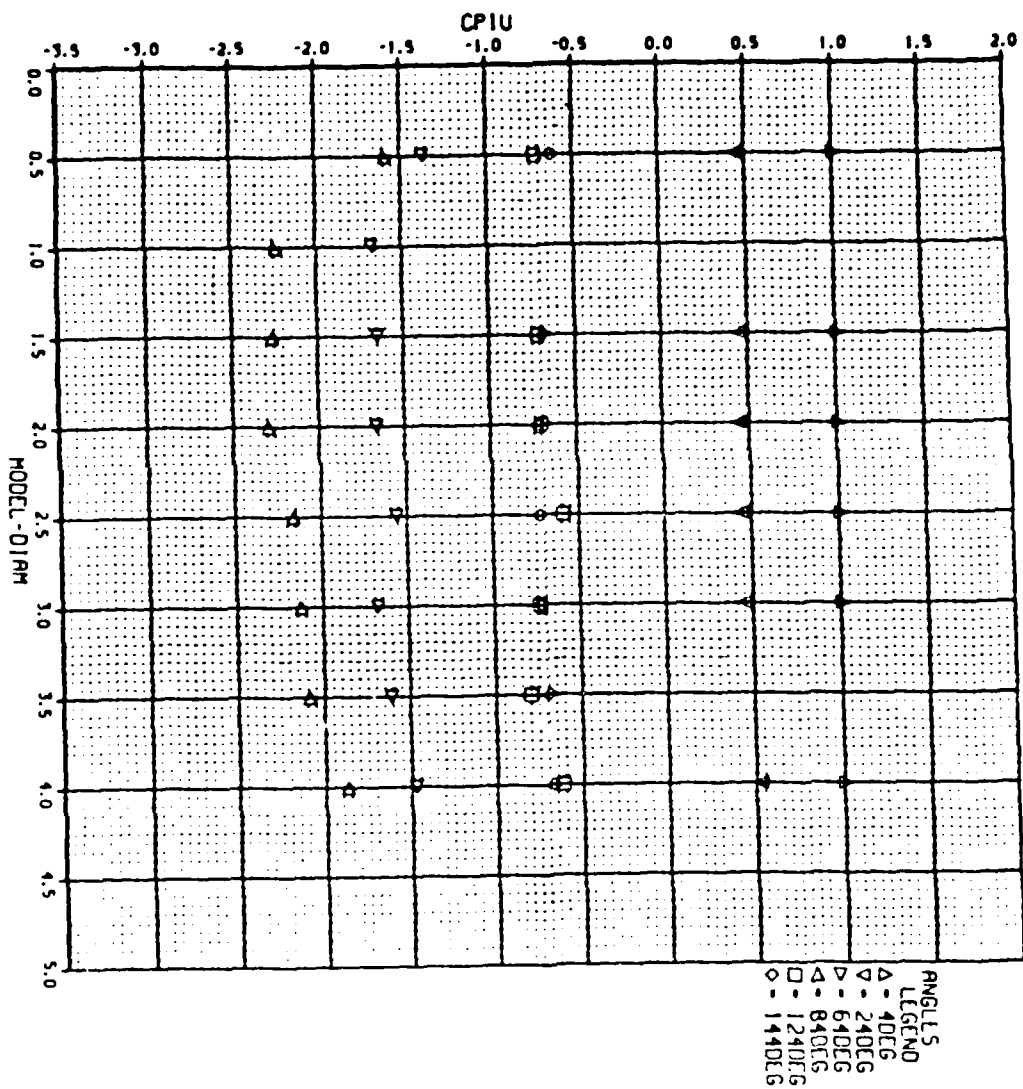
6.00: 5.00 DUNC PRESS. COEFFICIENTS CL- 0.0914 CO- 0.4735 RND-6.726



226,1,12 5.00: 5.00 QUNC PRESS. COEFFICIENTS CL- 0.0518 CD- 0.4930 RND-7.683

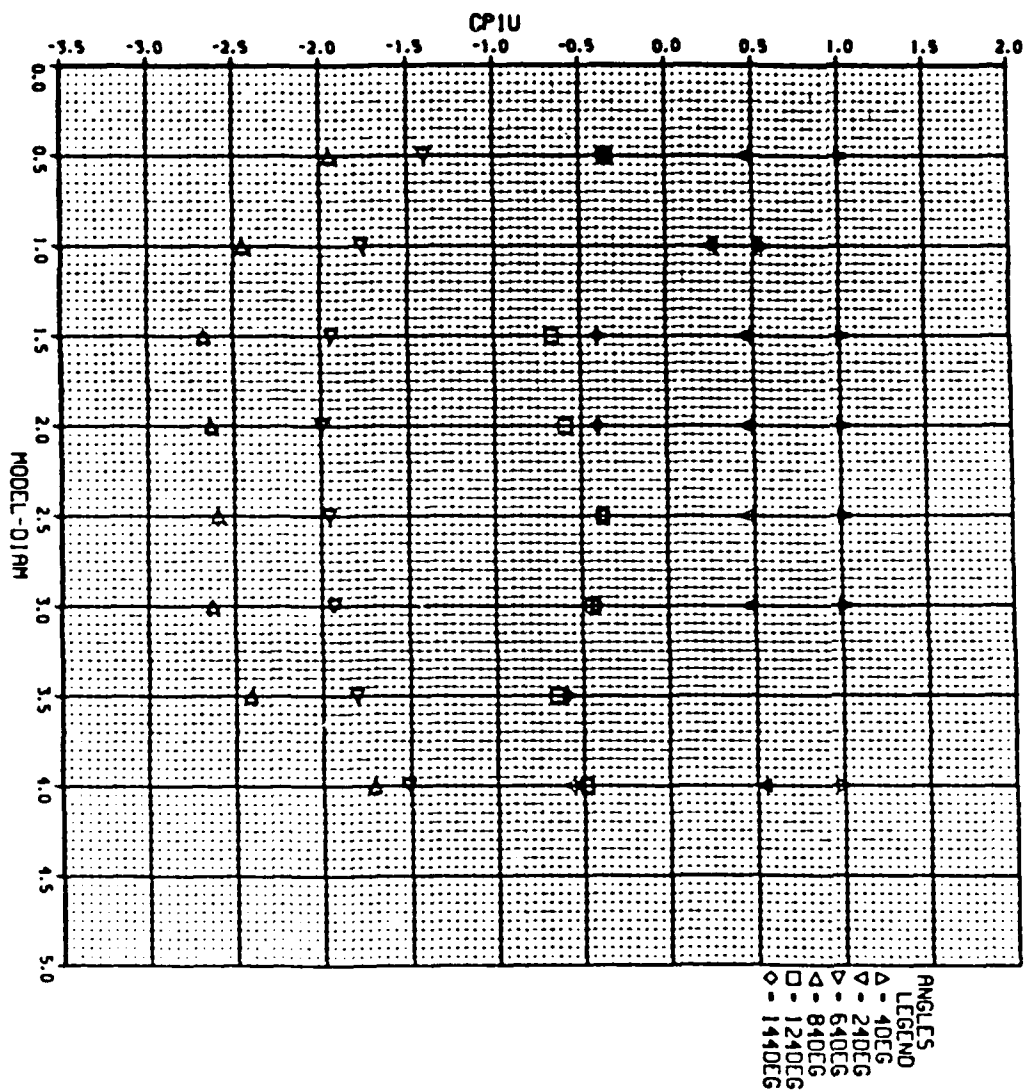


226,1,12 5.00, 5.00 LONGITUDINAL PRESSURE COEFFICIENTS

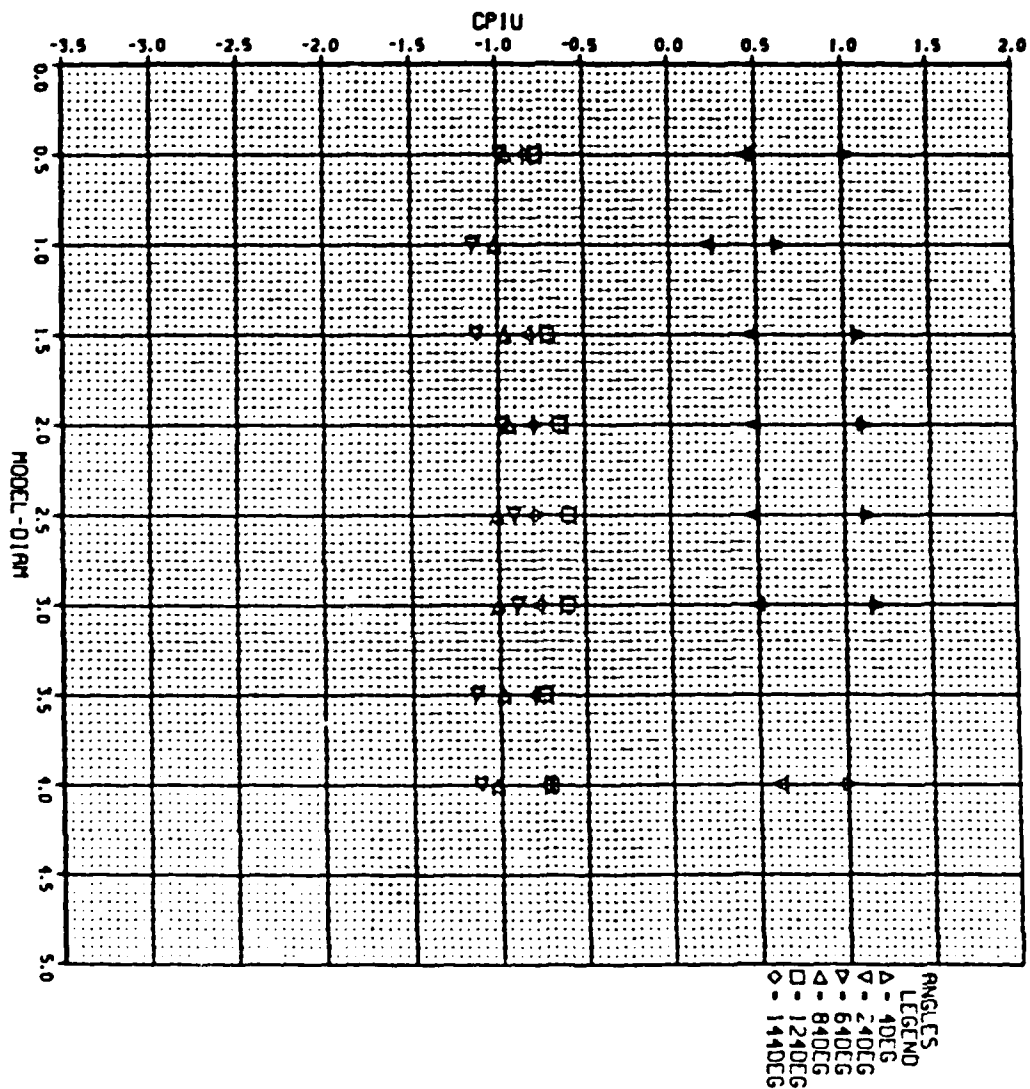




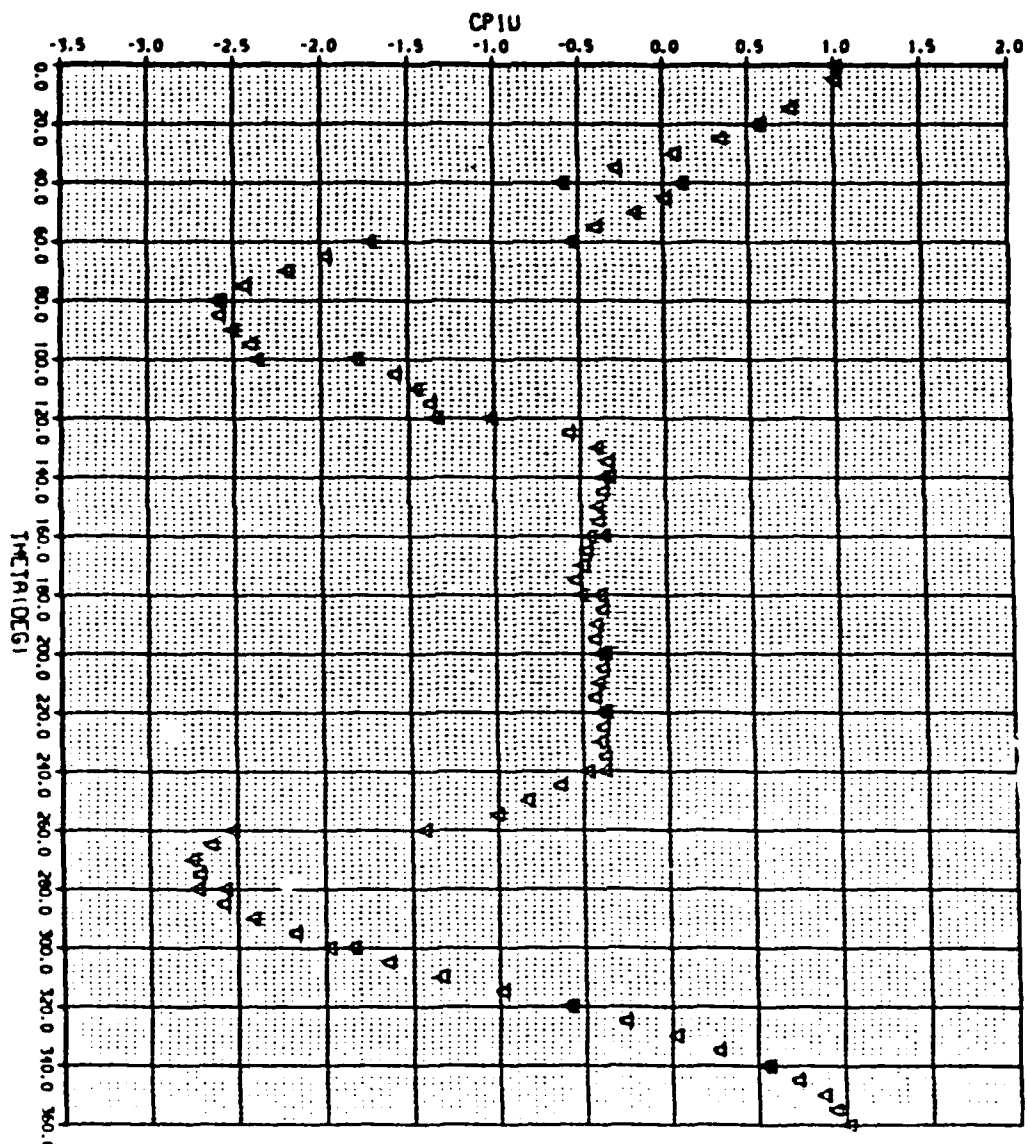
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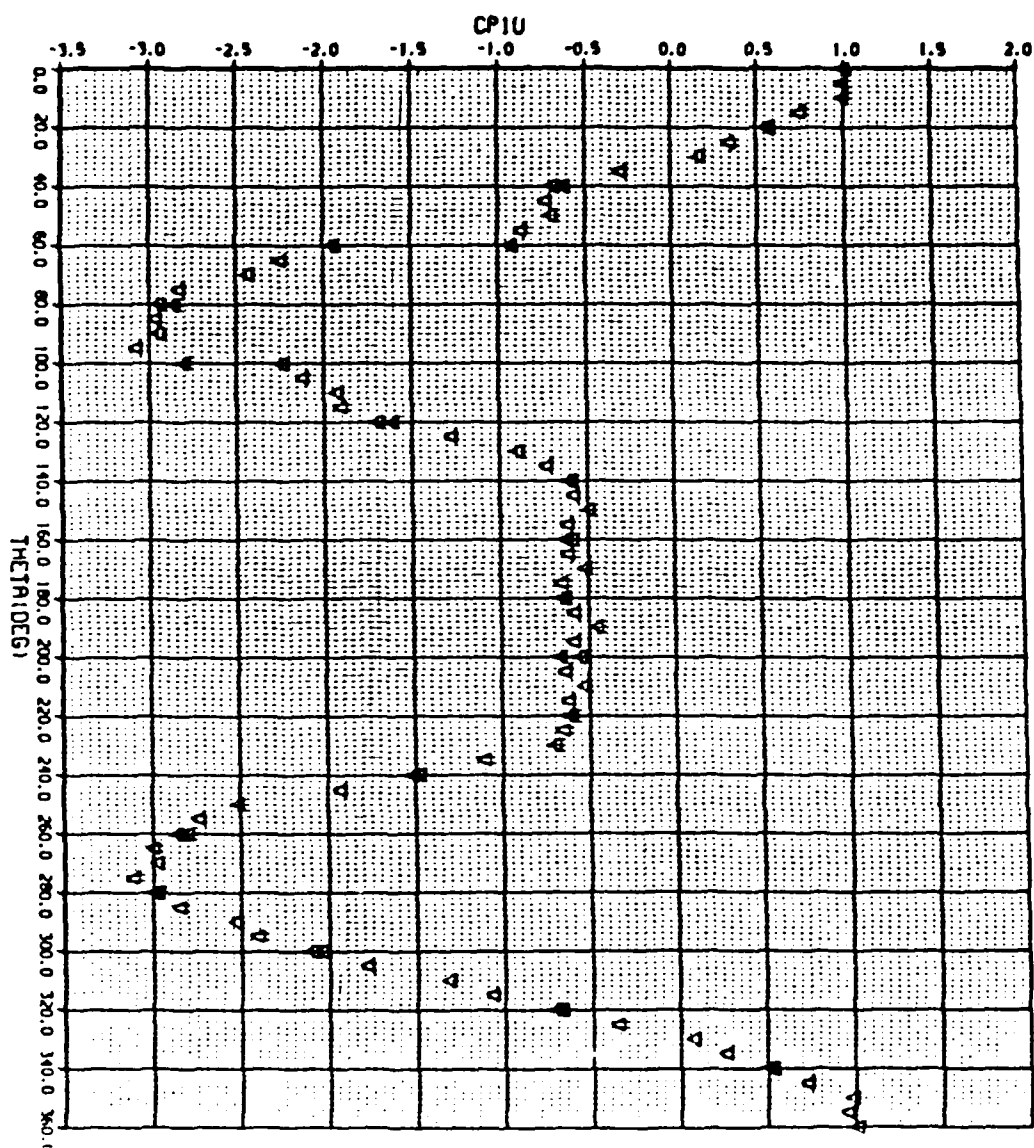
226,1,12 21.00: 5.00 LONGITUDINAL PRESSURE COEFFICIENTS



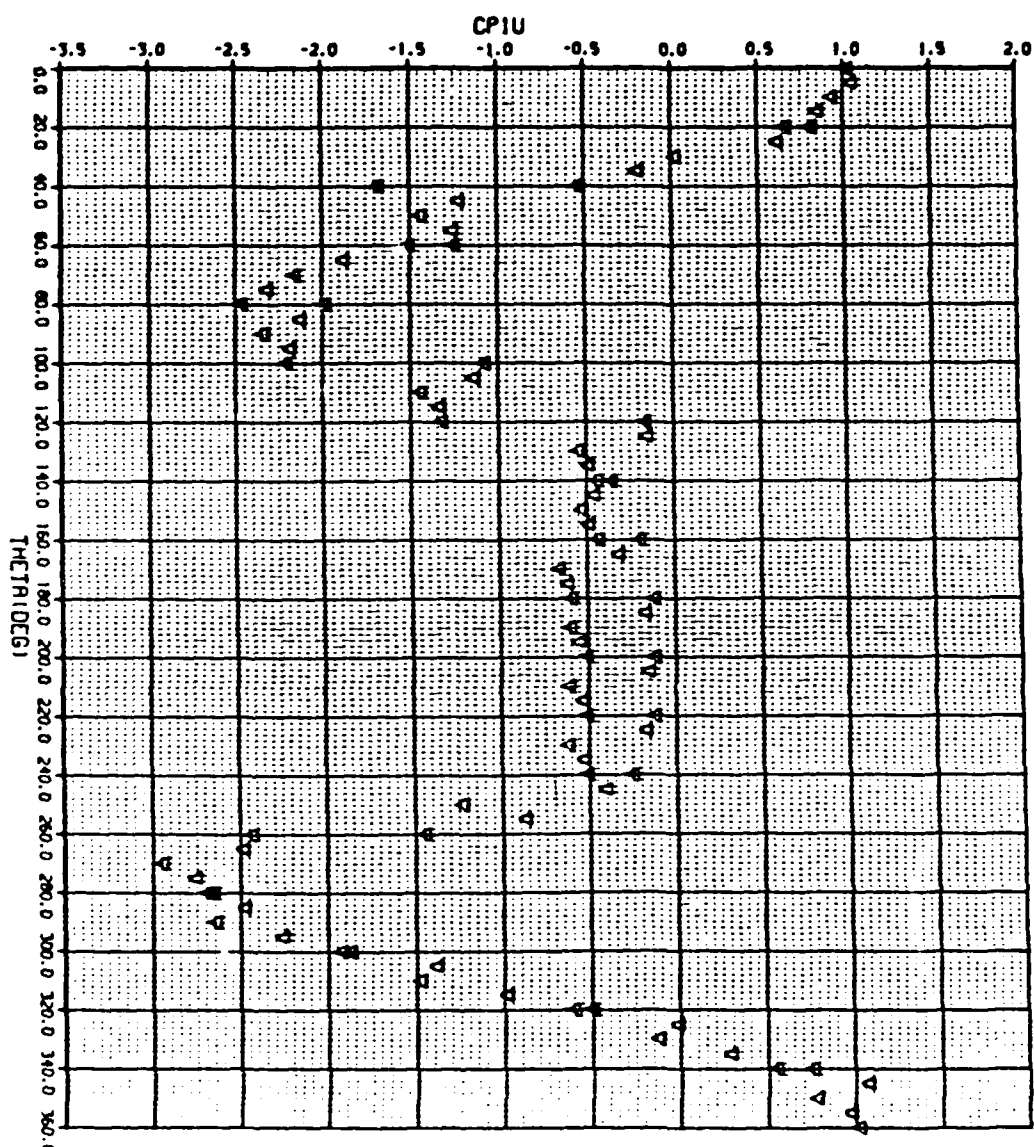
226.2,12 171.00; 5.00 QUNC PRESS. COEFFICIENTS CL--0.9019 CO- 5.0454 RND-0.410



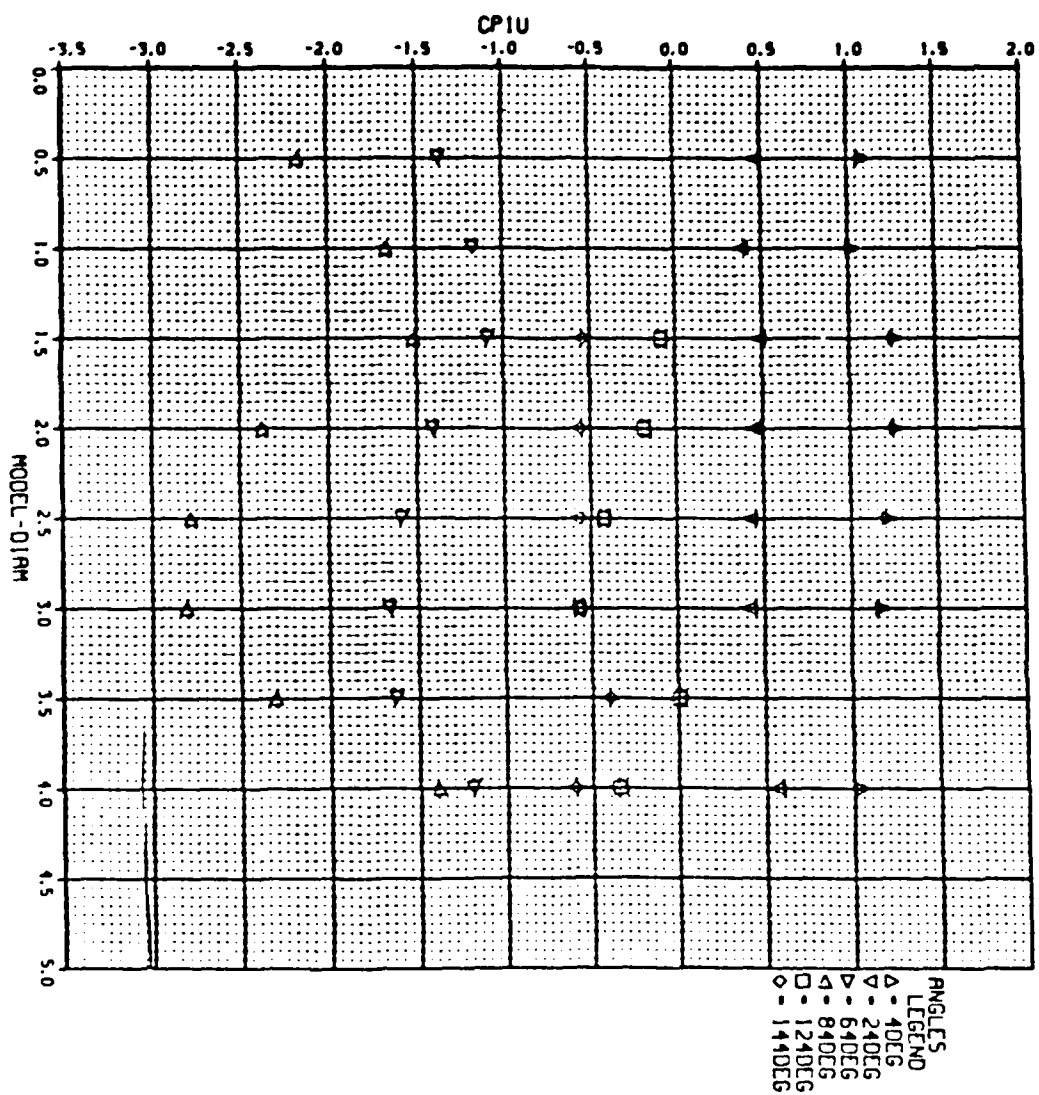
226,2,12 189.001 5.00 DMC PRESS. COEFFICIENTS CL--0.1571 CD- 0.6067 RND-0.515



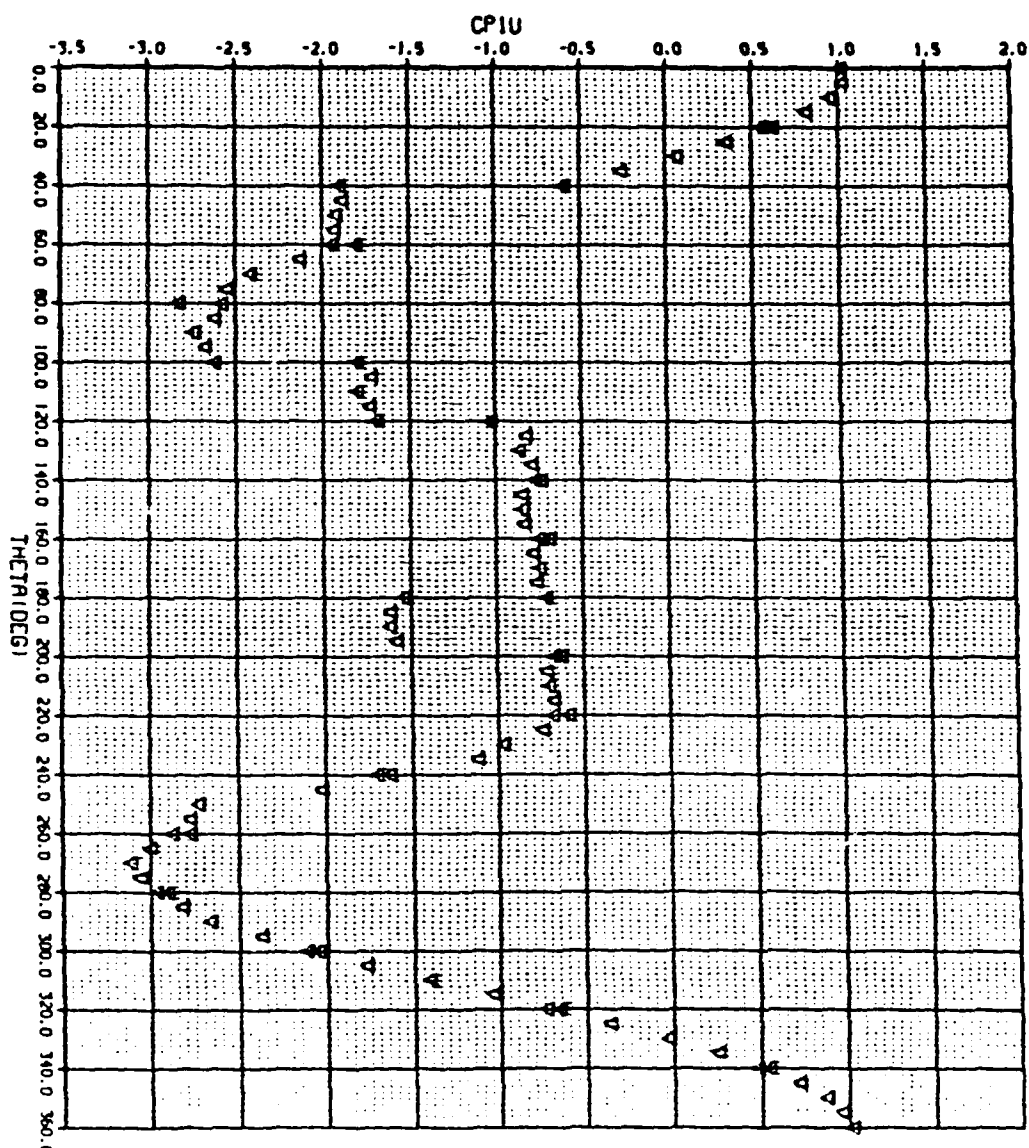
226,2,12 172.00, 5.00 QMC PRESS. COEFFICIENTS CL=-0.0737 CO= 0.2957 RND=0.503



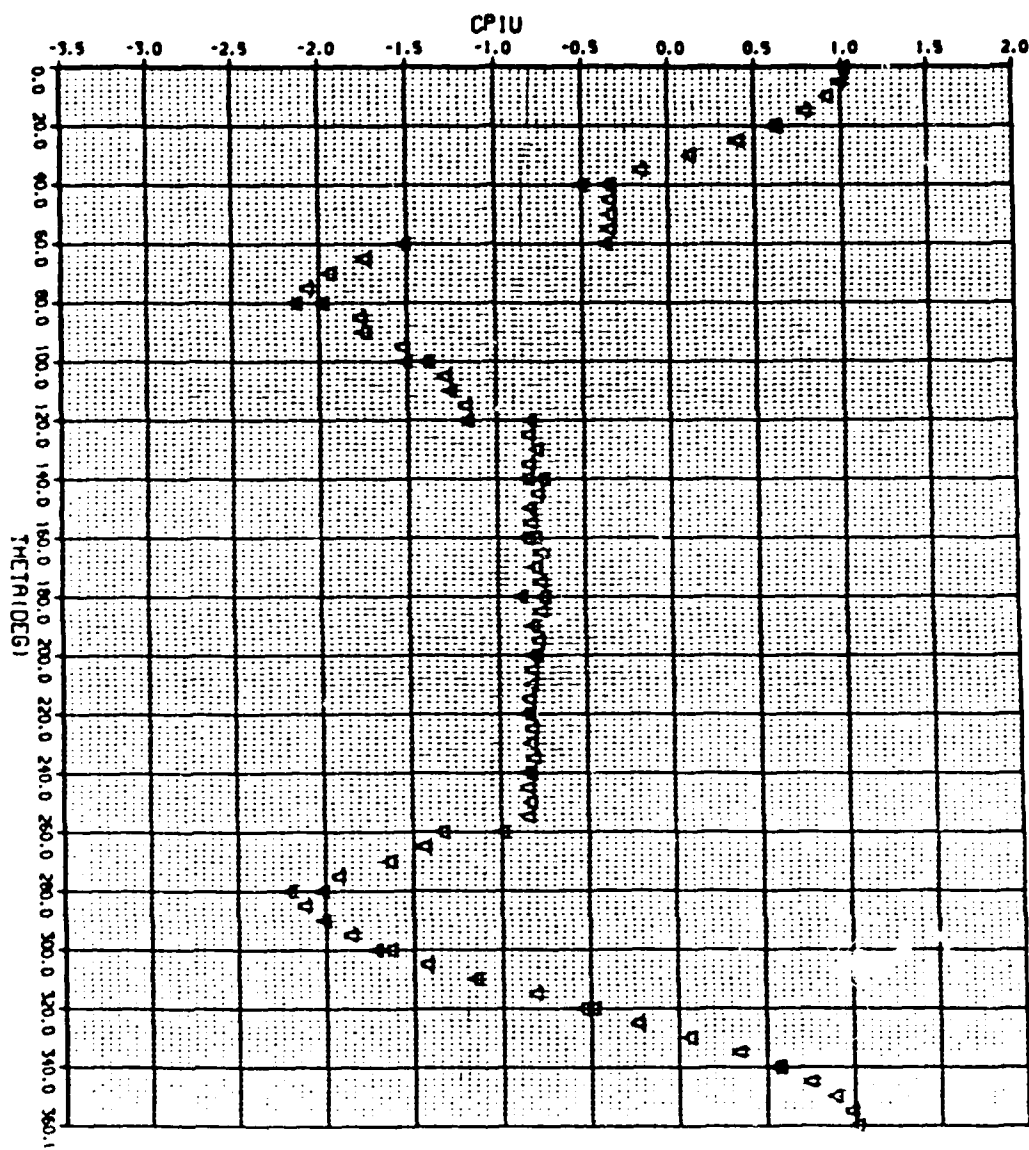
226.2.12 172.00: 5.00 LONGITUDINAL PRESSURE COEFFICIENTS



226,2.12 192.00: 5.00 QMC PRESS. COEFFICIENTS CL--0.1900 CD- 0.7011 RND-0.649

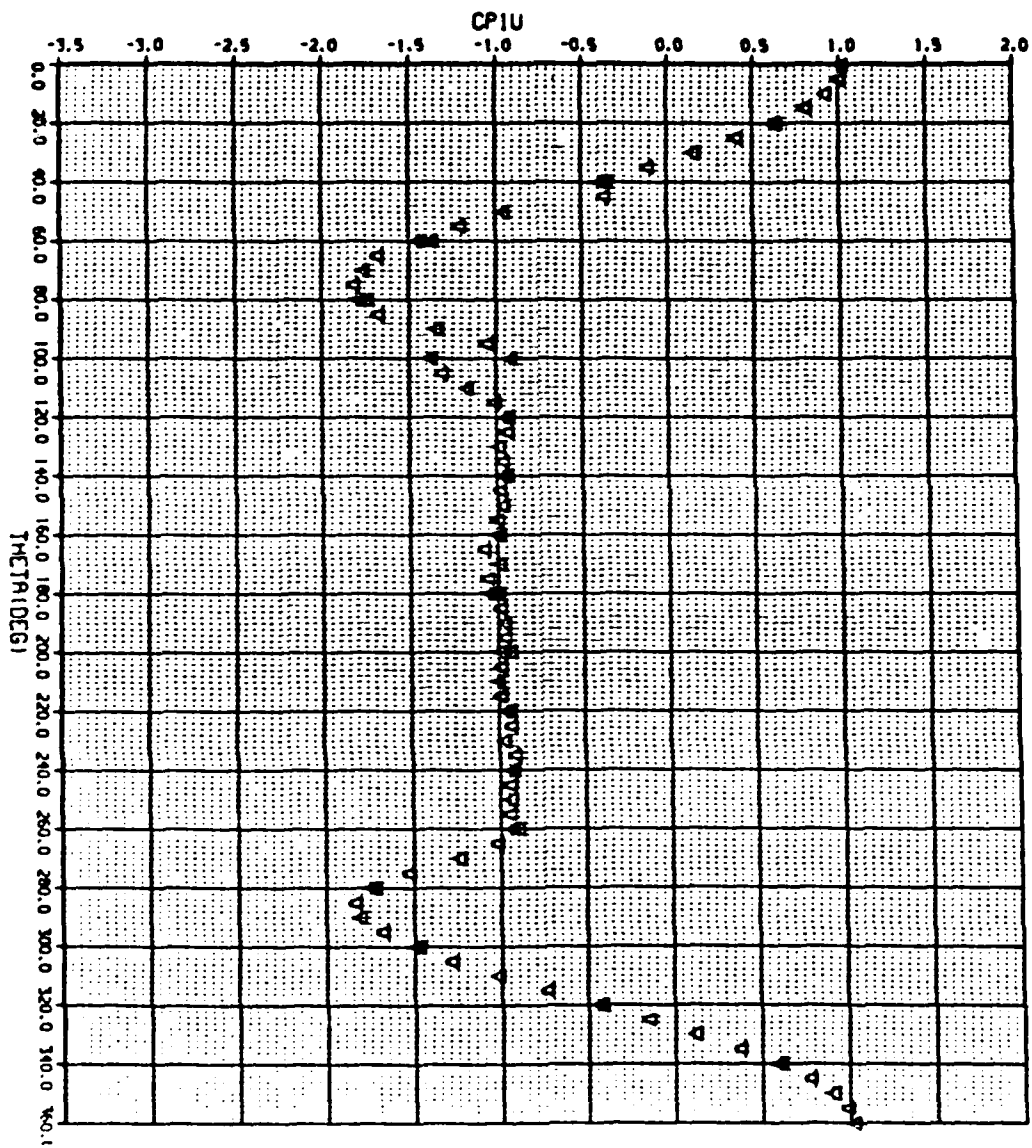


226.2,12 199.00: 5.00 QUNC PRESS. COEFFICIENTS CL=-0.0626 CD= 0.7516 RND=1.533

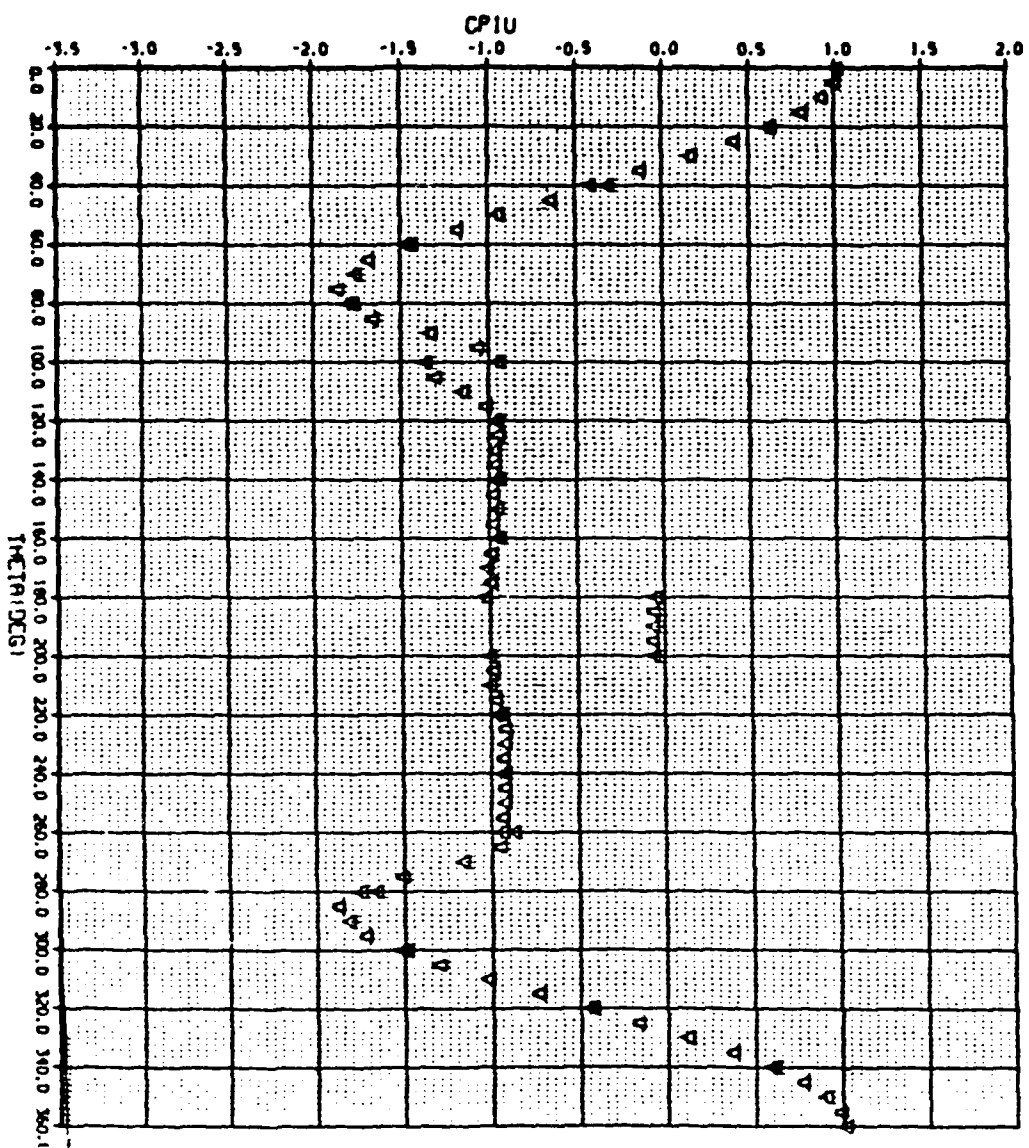




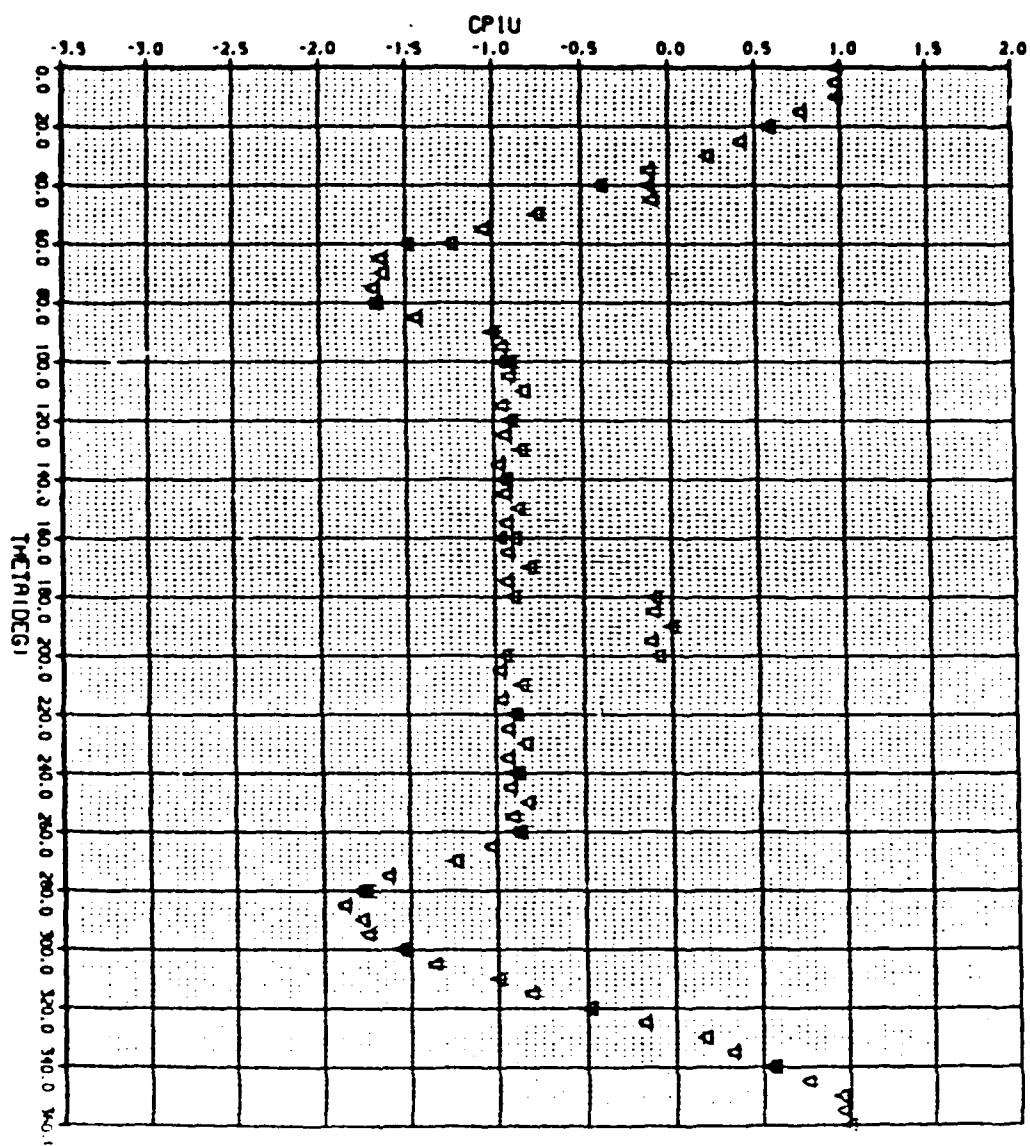
226,2,12 202.00: 5.00 DMC PRESS. COEFFICIENTS CL= 0.0271 CD= 0.9097 RND=3.121



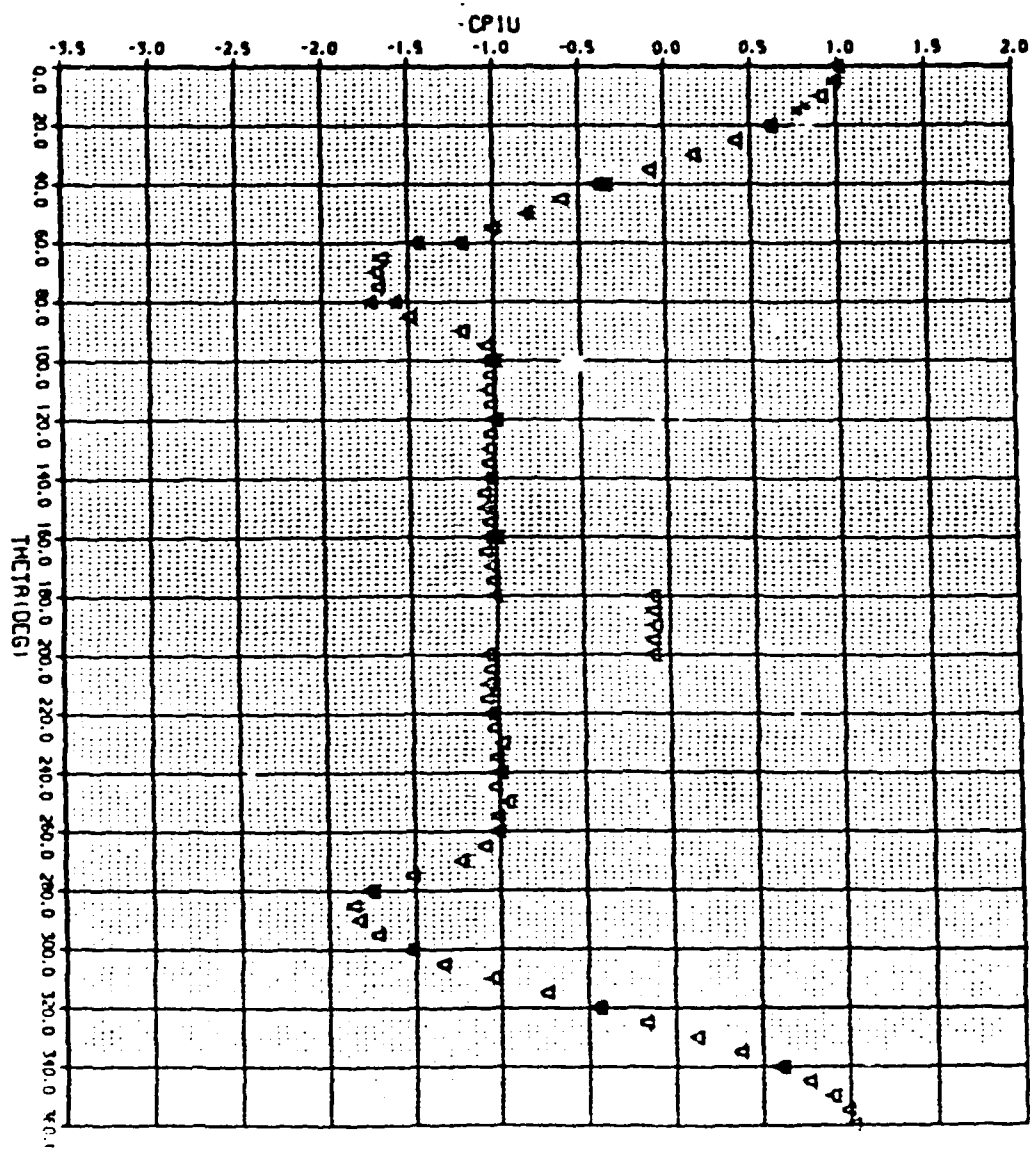
226.2.12 205.00: 5.00 QUNC PRESS. COEFFICIENTS CL- 0.0682 CO- 0.7293 RND-6.182



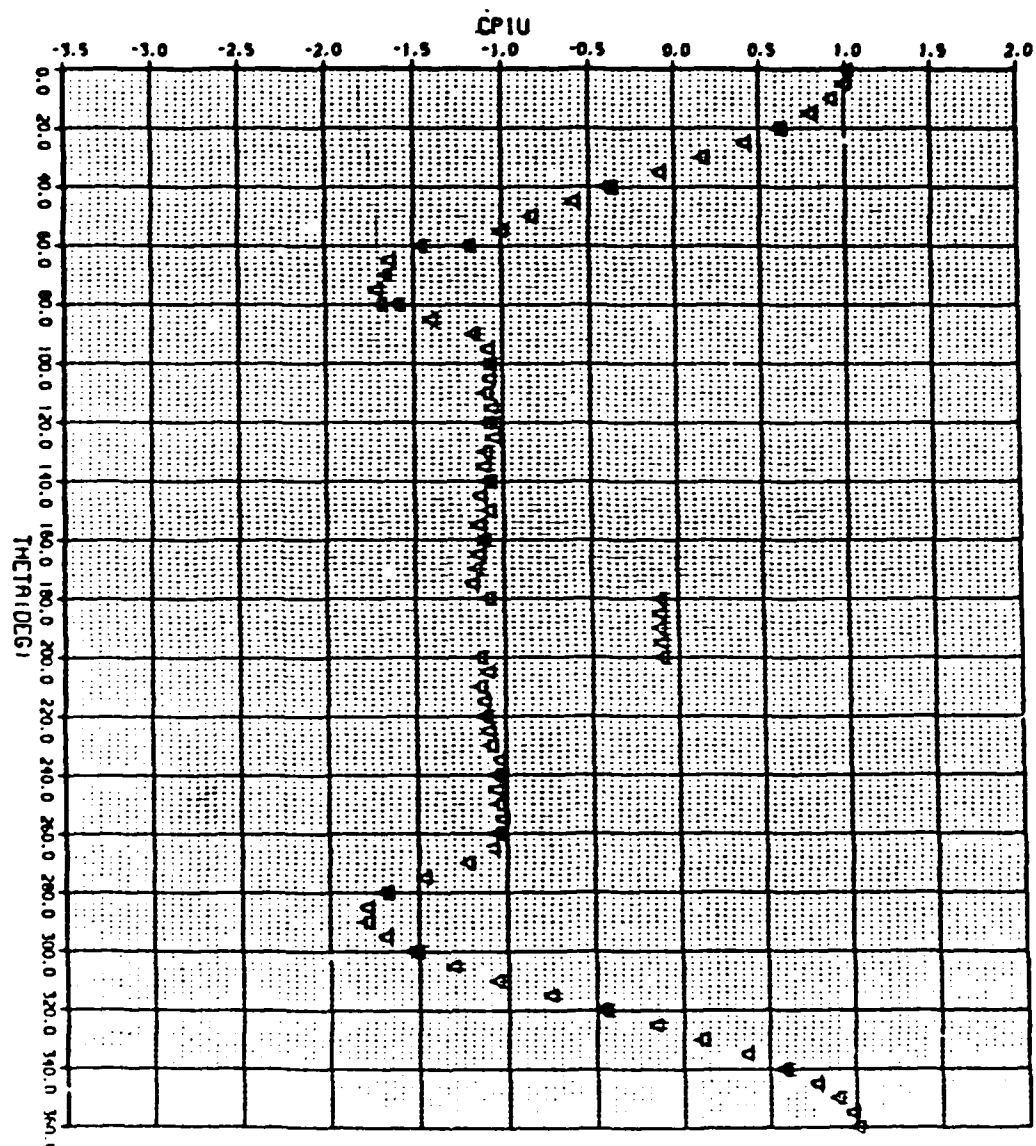
226,2,12 226.001 5.00 QMC PRESS. COEFFICIENTS CL=-0.0717 CD= 0.7036 RND=0.444



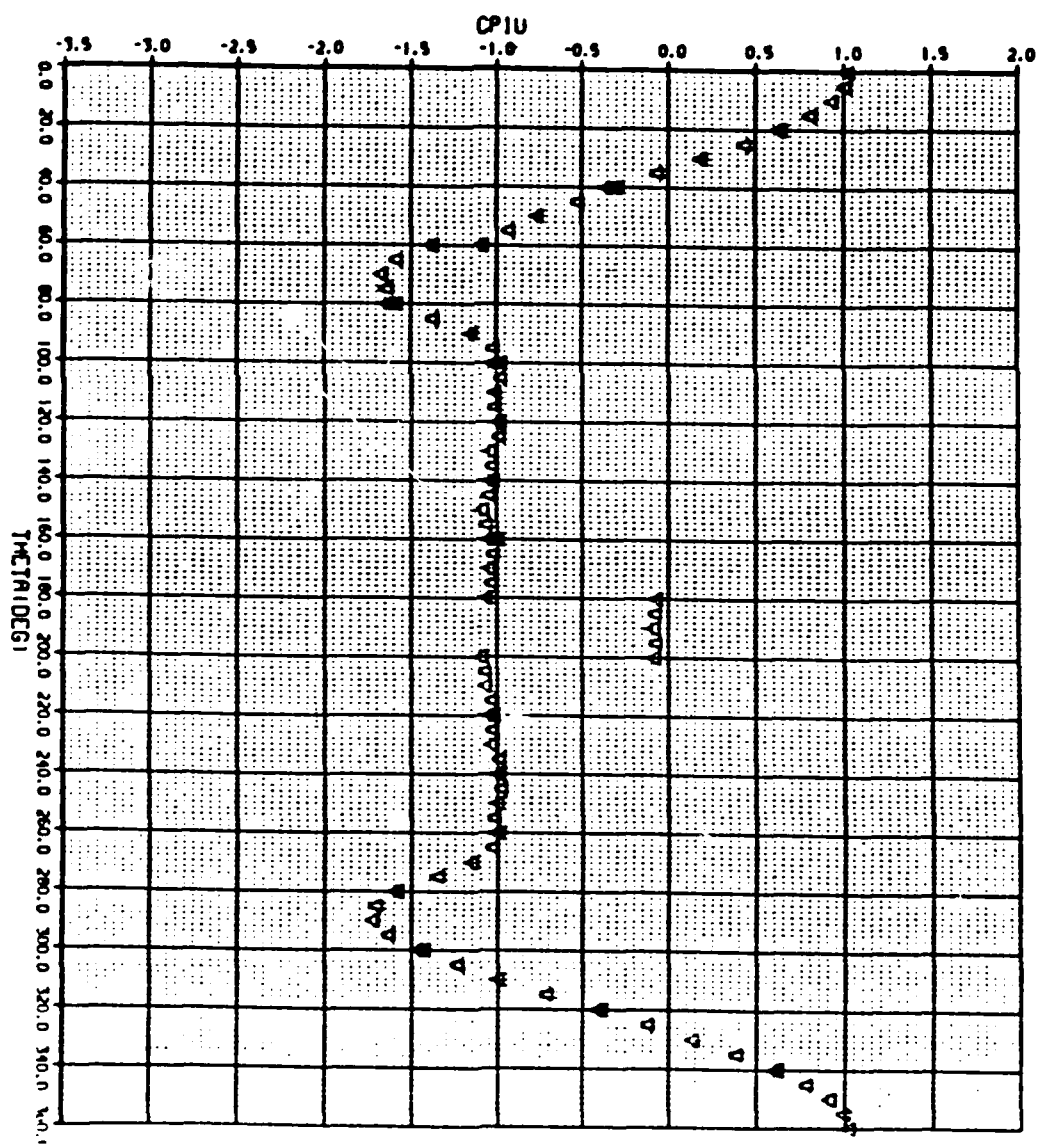
226.2,12 229.00: 5.00 QMC PRESS. COEFFICIENTS CL--0.0297 CD- 0.7954 RND-0.725



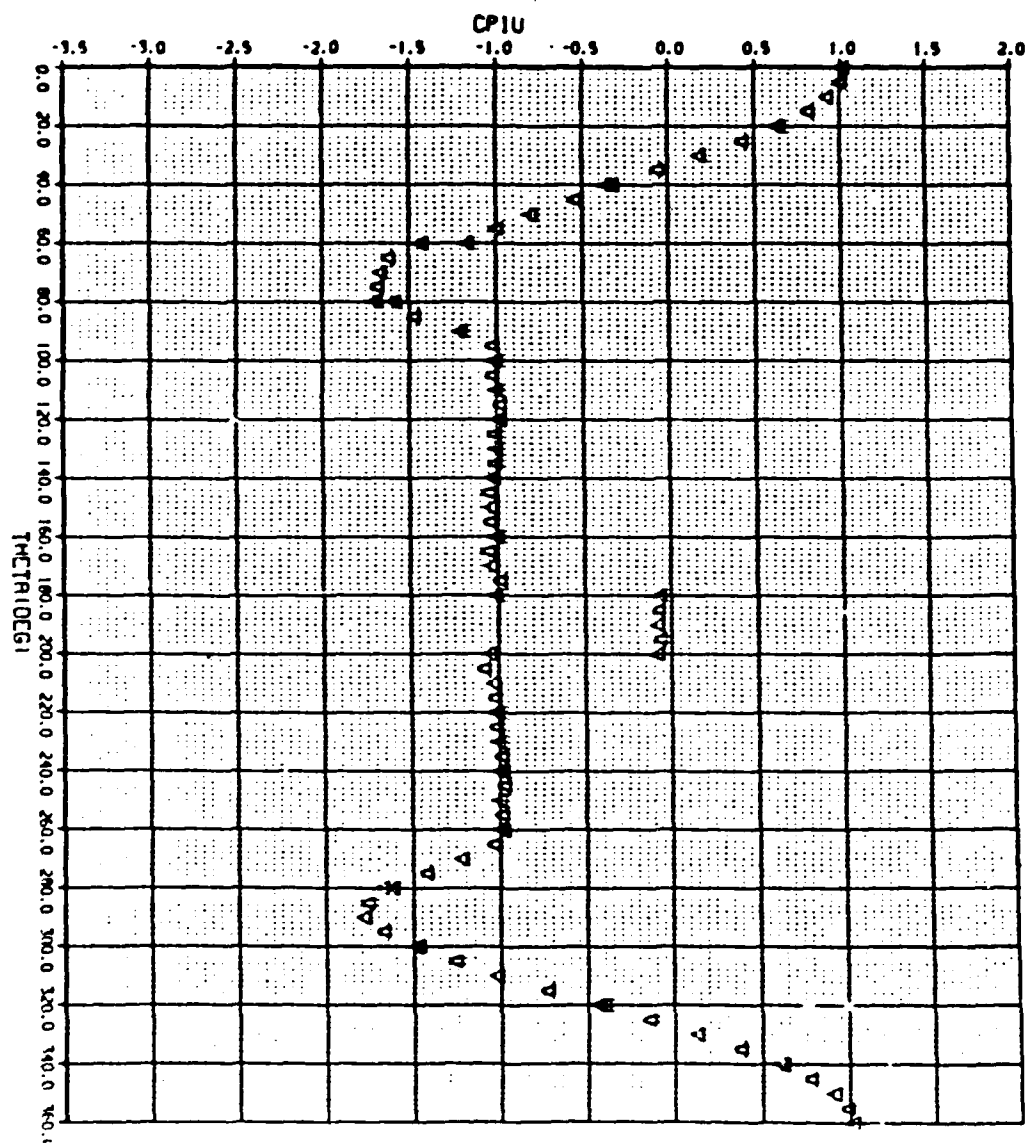
226,2.12 233.00: 5.00 QMC PRESS. COEFFICIENTS CL=-0.0185 CO=0.8593 RND=1.279



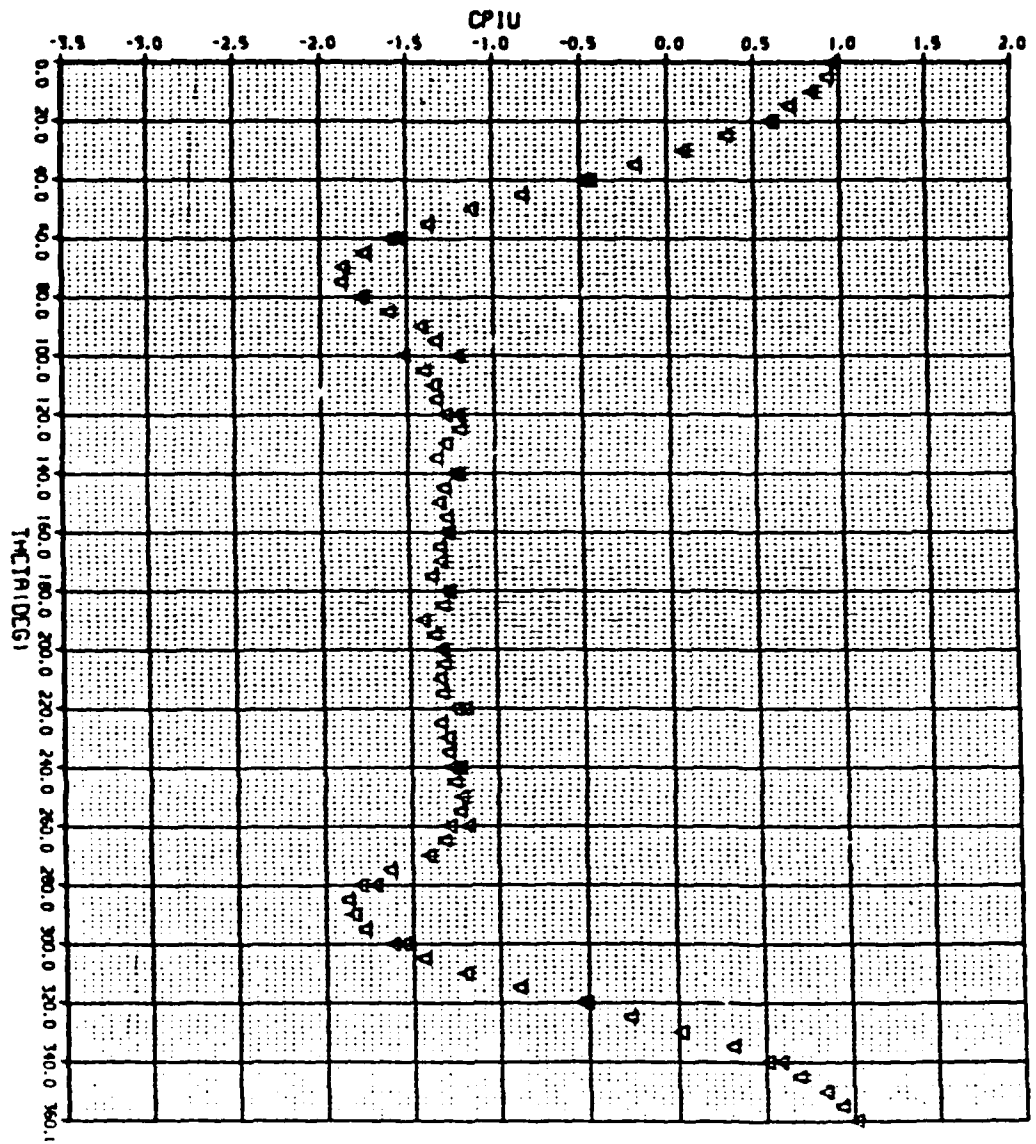
226.2,12 239.001 5.00 QMC PRESS. COEFFICIENTS CL--0.0152 CD- 0.8298 RND-3.093



226,2,12 243,00: 5,00 DMC PRESS. COEFFICIENTS CL--0,0152 CD- 0,8007 RND-7,270

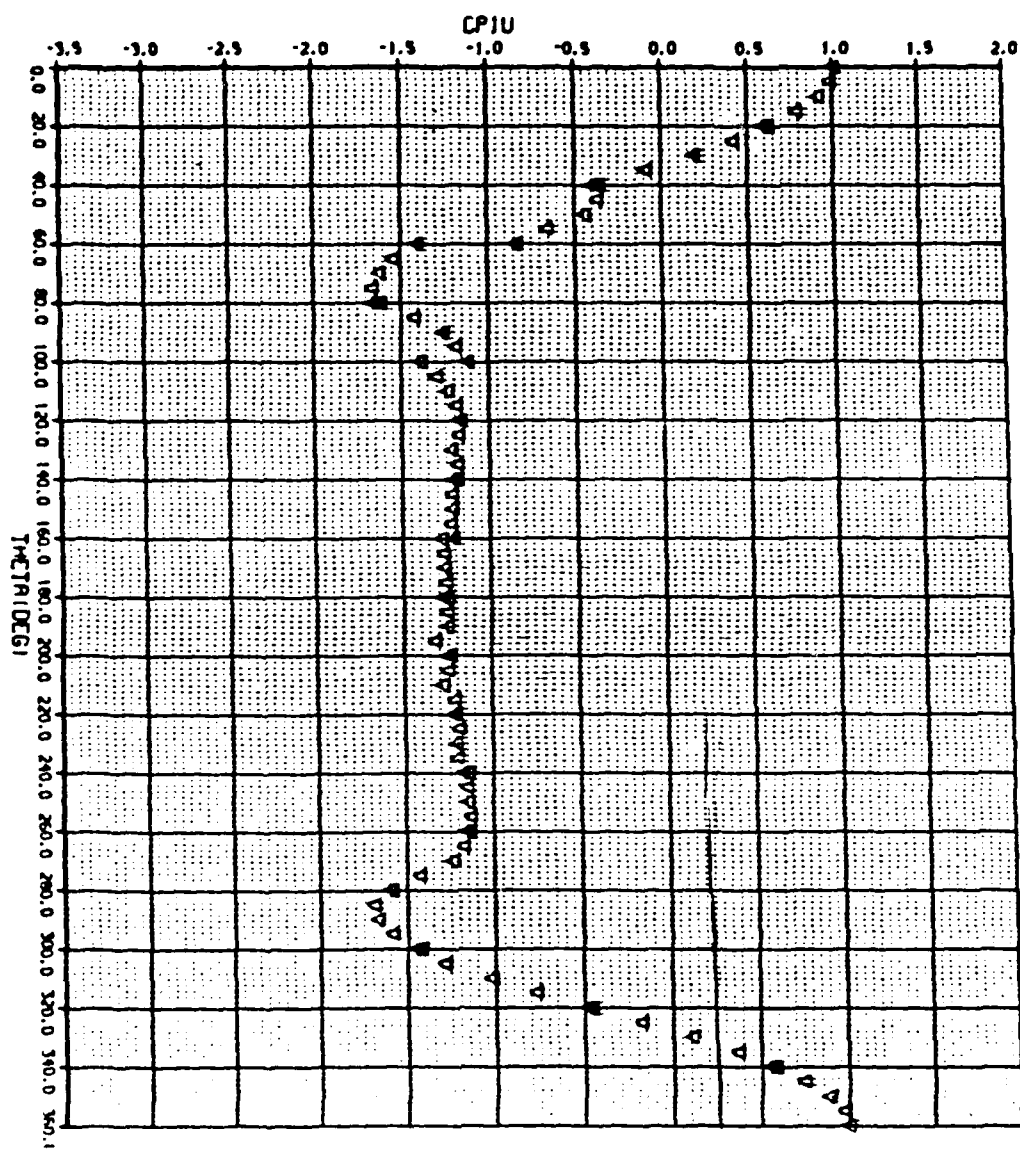


226,2.12 142.00: 5.00 QANC PRESS. COEFFICIENTS CL- 0.0044 CD- 1.1244 RND-0.417

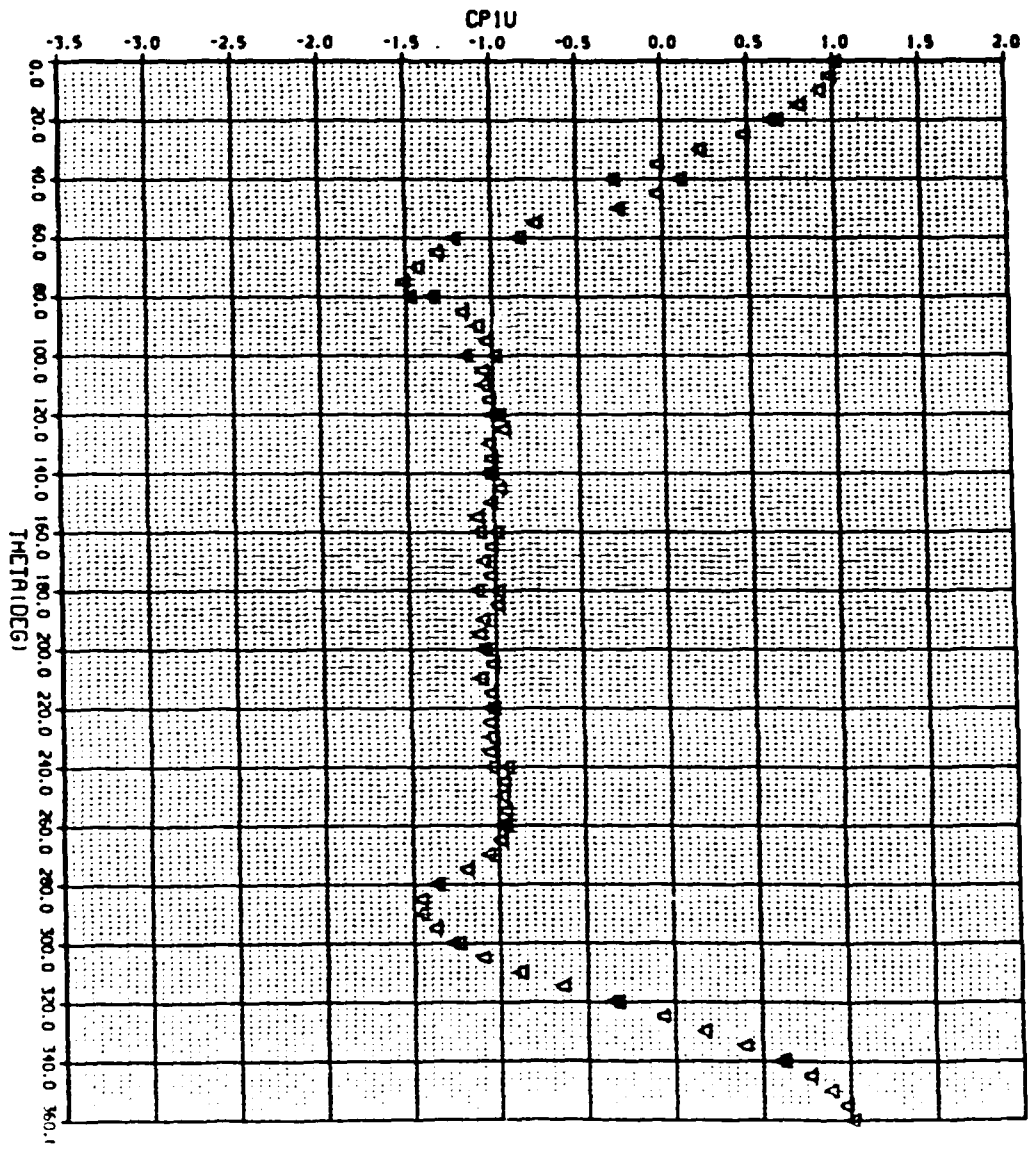




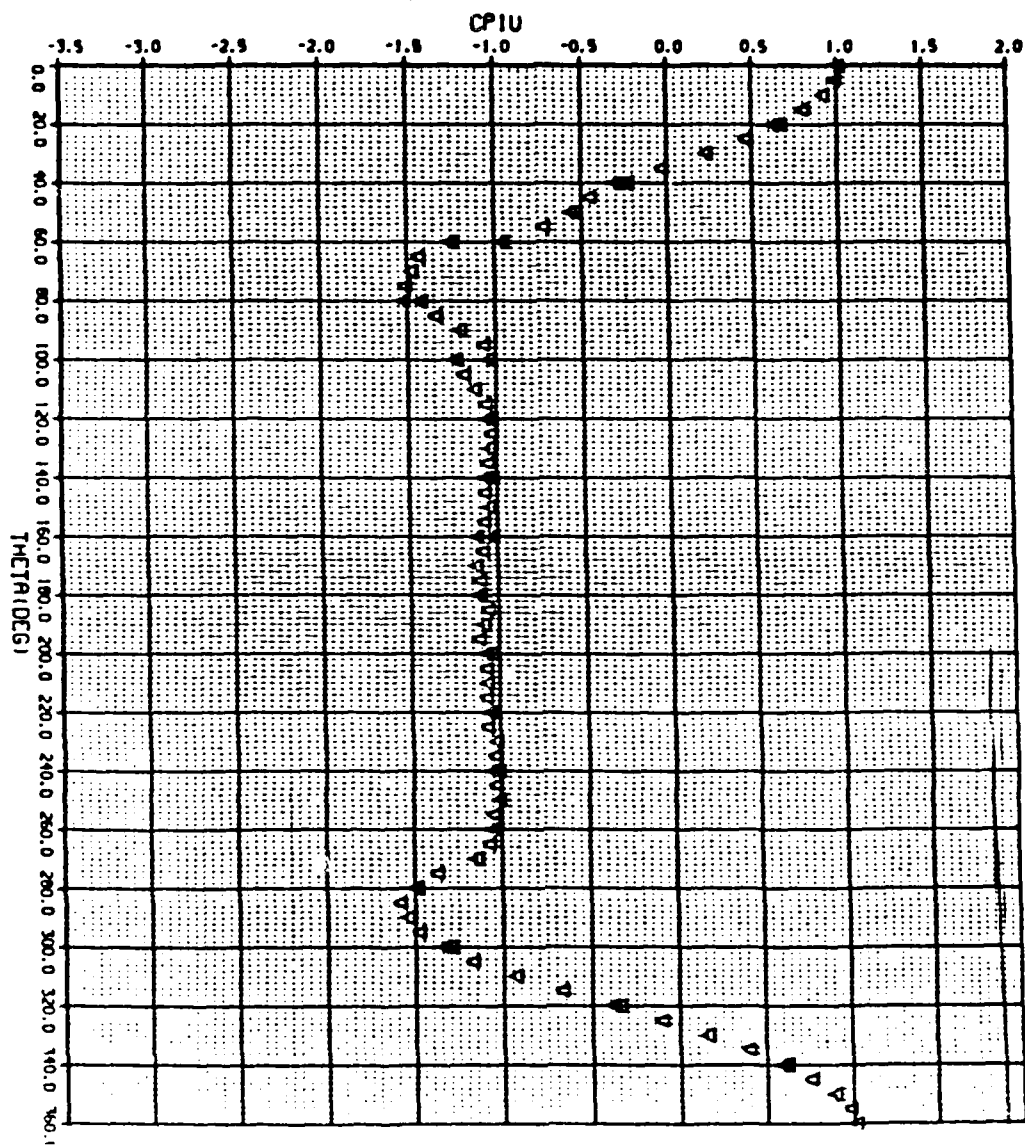
226,2.12 147.00: 5.00 QMC PRESS. COEFFICIENTS CL--0.0604 CD- 1.1907 RND-0.949



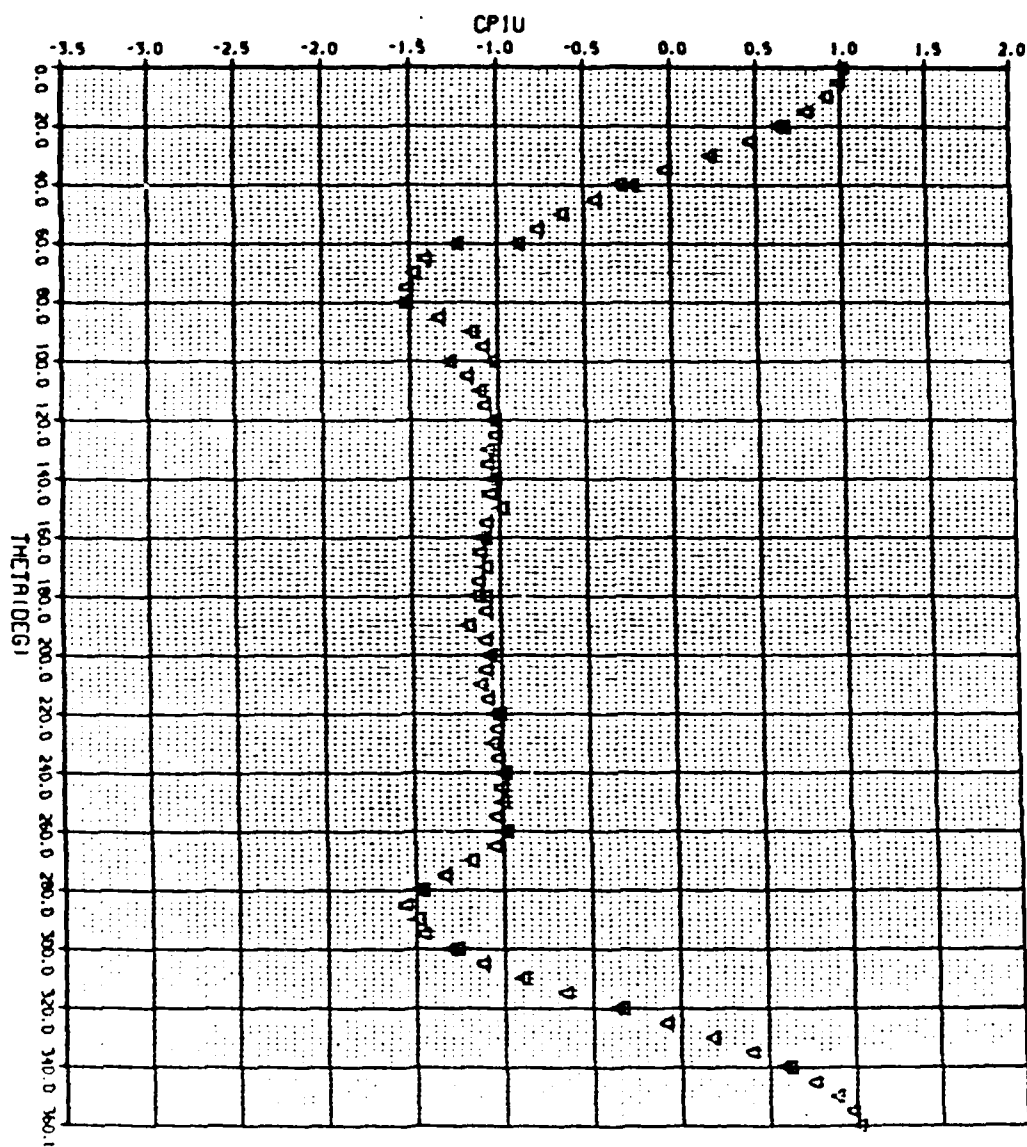
226.2,12 139.00: 5.00 QMC PRESS. COEFFICIENTS CL--0.0629 CD- 1.0840 RND-1.533



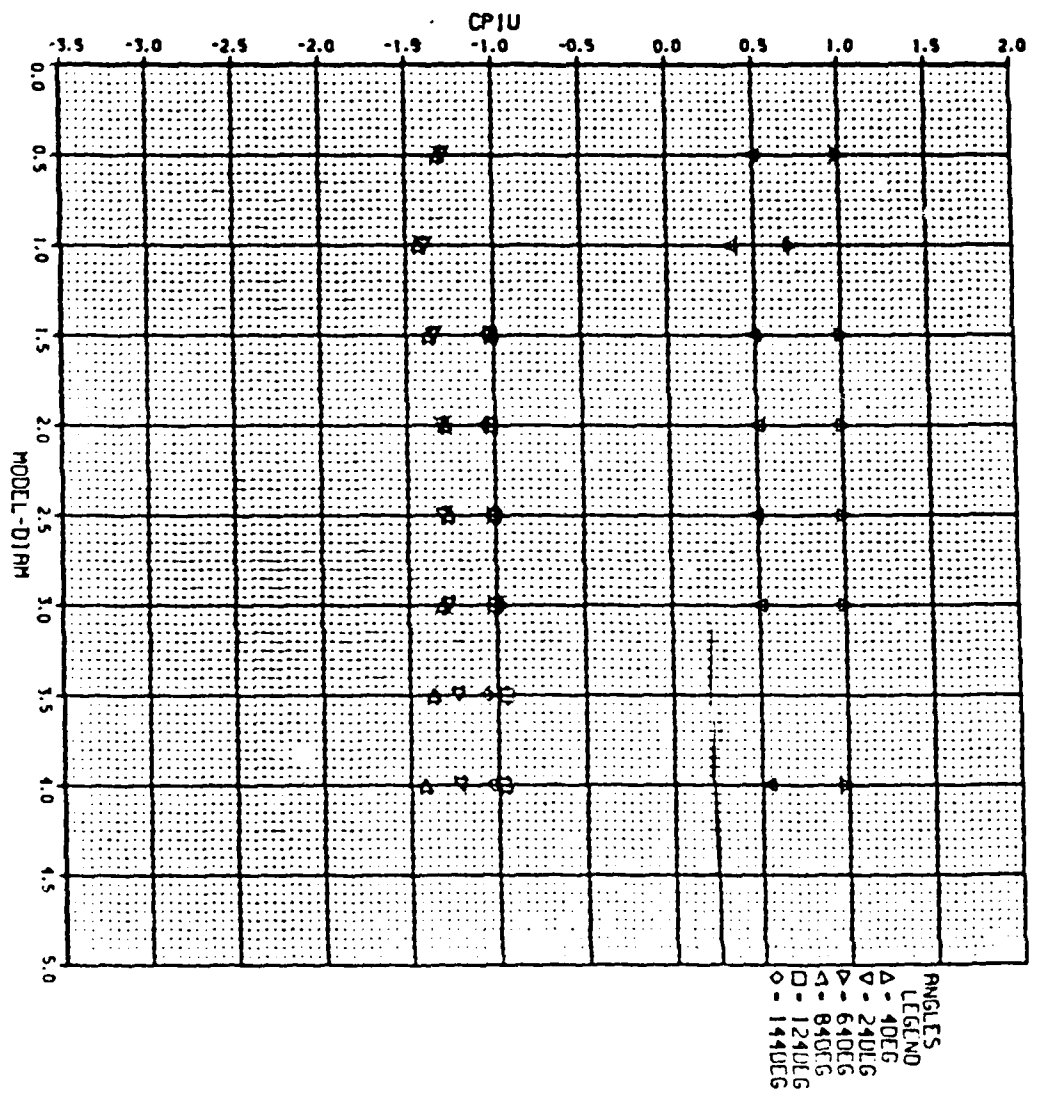
226.2,12 134.00: 5.00 QUNC PRESS. COEFFICIENTS CL=-0.0427 CD= 1.0750 RND=4.188



226.2.12 132.00: 5.00 DMC PRESS. COEFFICIENTS CL--0.0279 CD- 1.0831 RND-6.586



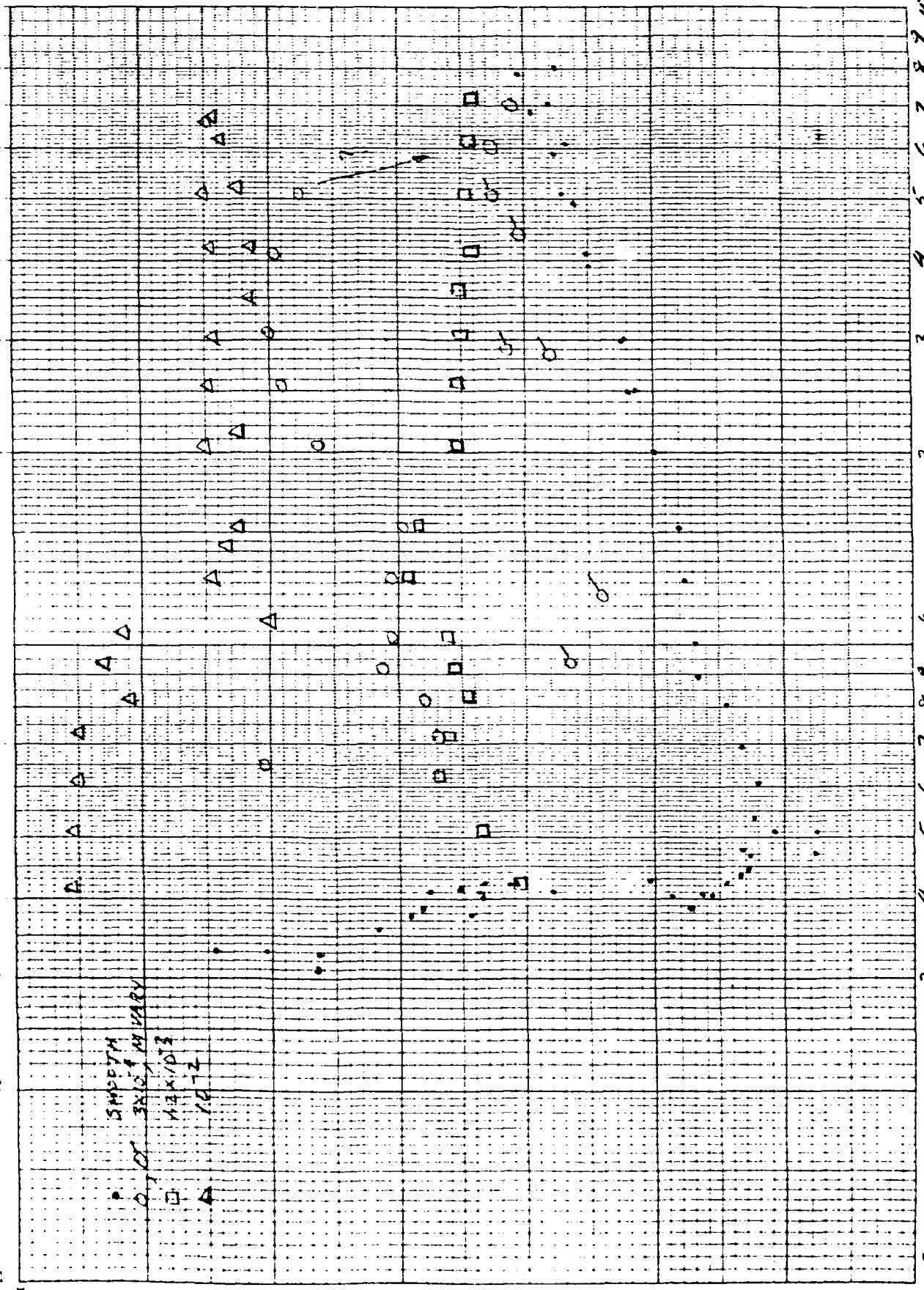
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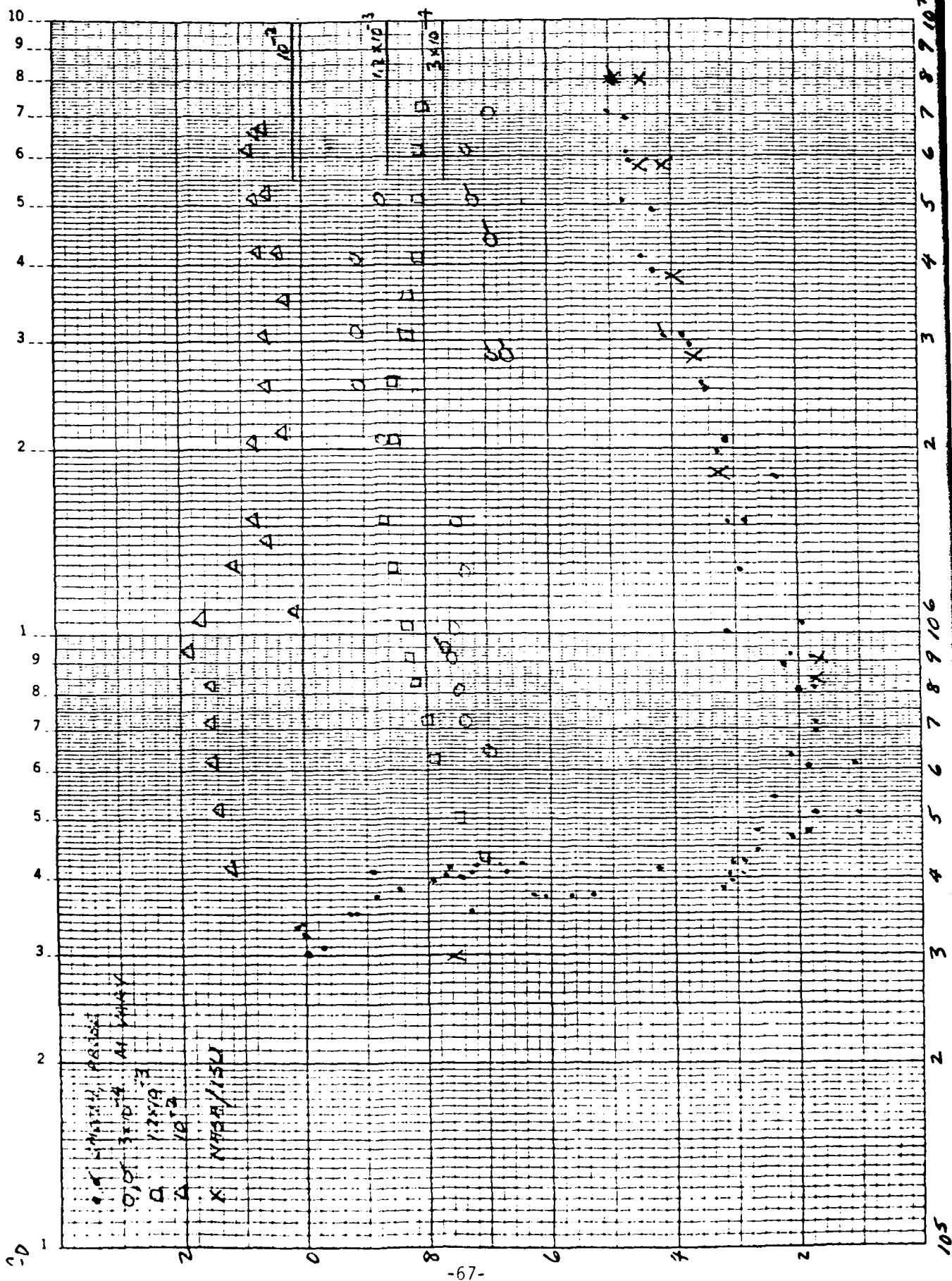
46 4973

K-S SEMI-LOGARITHMIC PLOT OF  $\sigma_c$  VS.  $\sigma_t$  FOR  
KUPFERSTEIN CO. STEEL

$\sigma_c$  (AVG)



**46 4973**



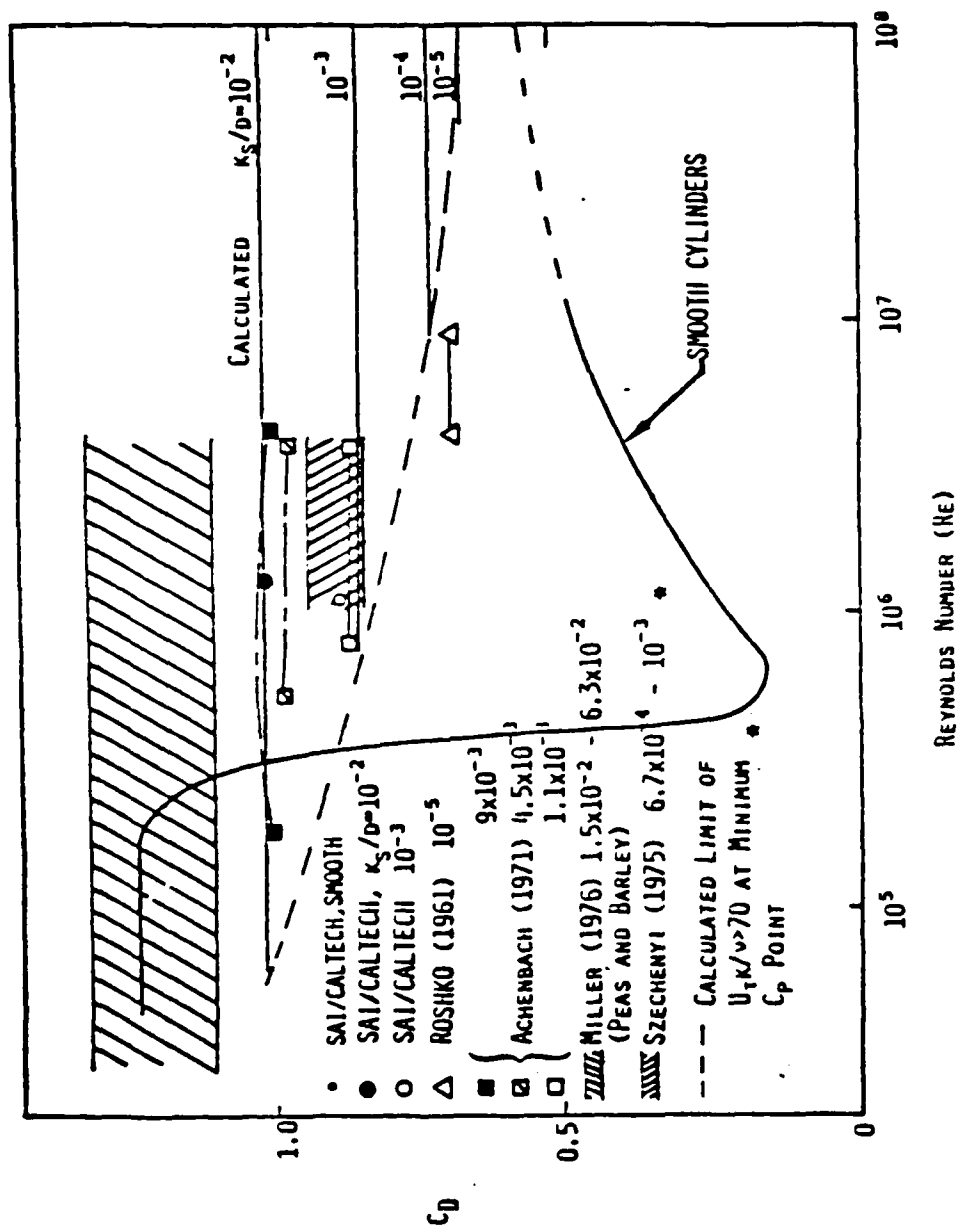
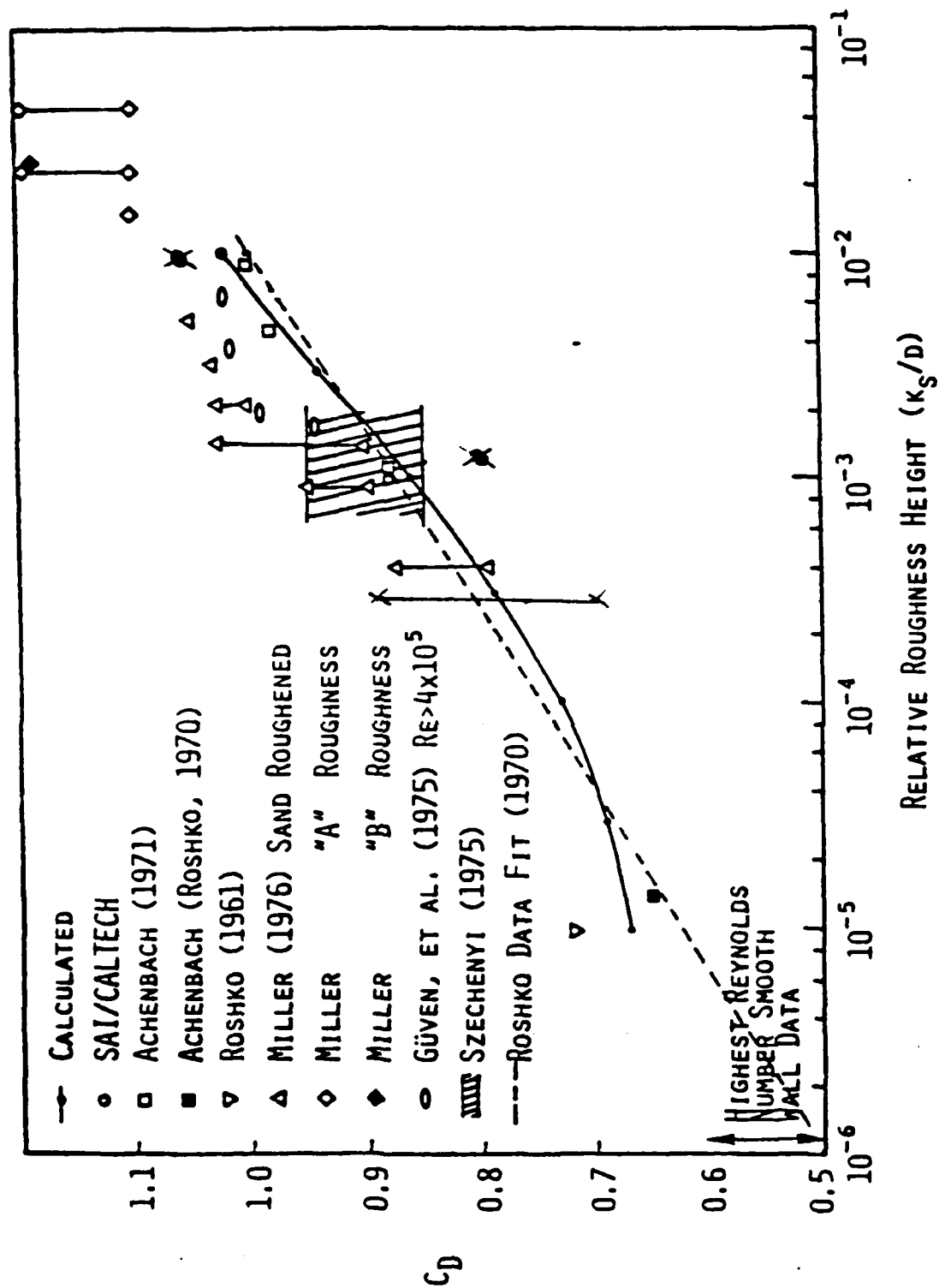


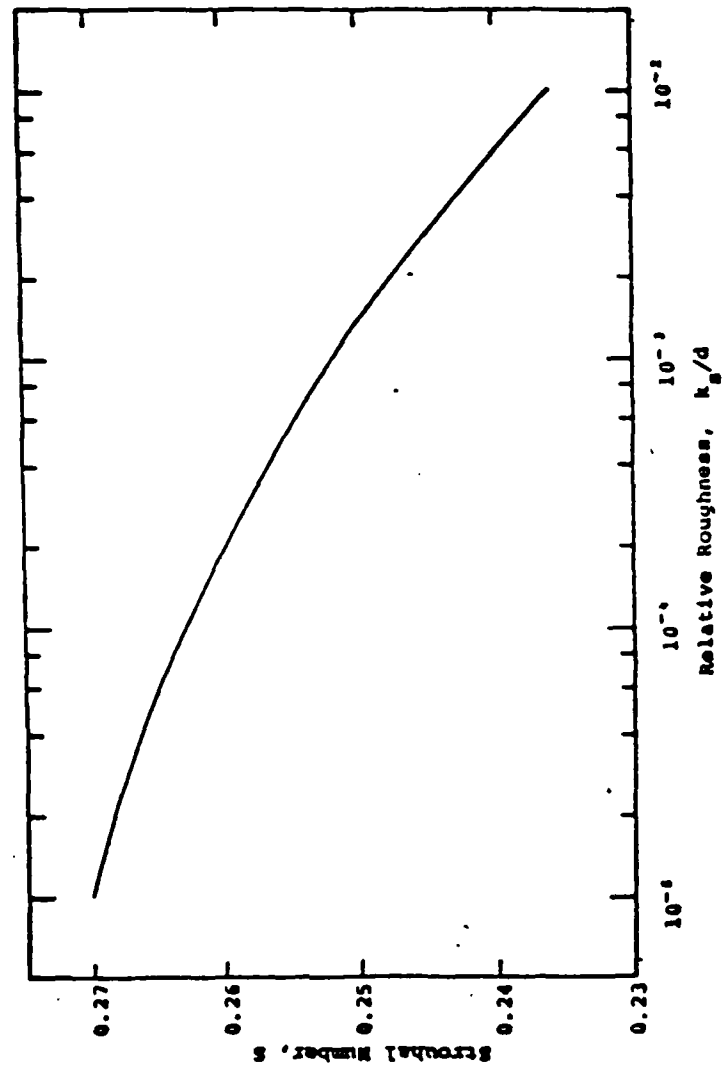
FIGURE 1.12 Drag Coefficient





Roughness Effect on Drag Coefficient





Effects of Relative Roughness on Strouhal Number in Reynolds Numbers Independence Regime

# BOUNDARY LAYER ANALYSIS

DATA: BL RAKE - 4 PITOTS, 1 STATIC

DEFINITIONS:  $\theta = \int_0^{\infty} \frac{u}{u_e} (1 - \frac{u}{u_e}) dy$ ;  $\delta^* = \int_0^{\infty} (1 - \frac{u}{u_e}) dy$

VELOCITY PROFILES:  $u/u_e = [(C_{pe} - C_{pe}) / (1 - C_{pe})]^{1/2}$

$$u^* = u/u_e = \frac{u}{u_e} (2/C_f)^{1/2}$$

$$y^* = \frac{u^* y}{d} = Re_d \frac{y}{d} \frac{u_e}{u_e} (C_f/2)^{1/2}$$

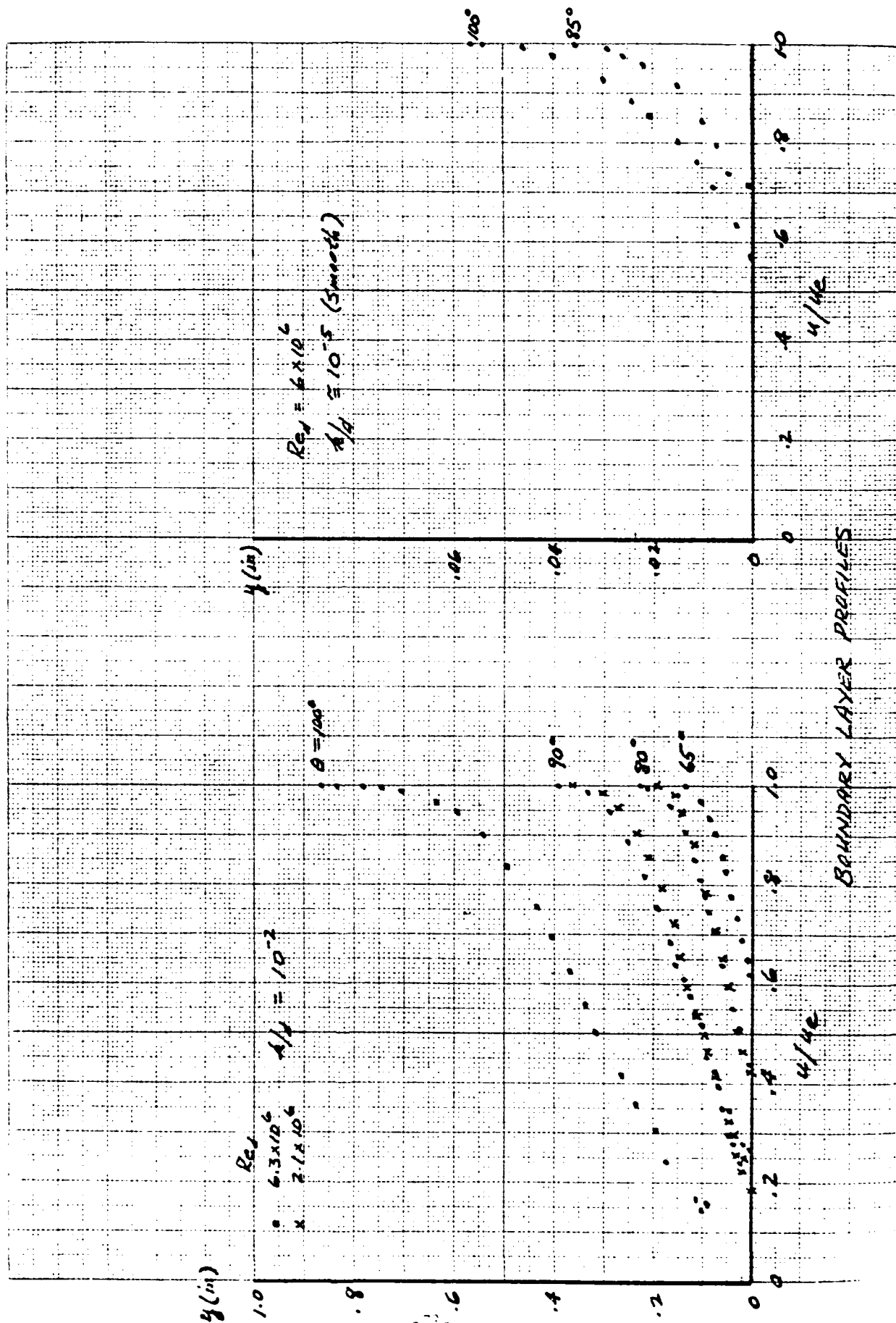
INTEGRAL MOMENTUM RELATION:

$$\frac{d\theta}{dx} + (2+H) \frac{\delta}{u_e} \frac{du_e}{dx} = \frac{C_f}{2}$$

$$H = \delta^* / \theta$$

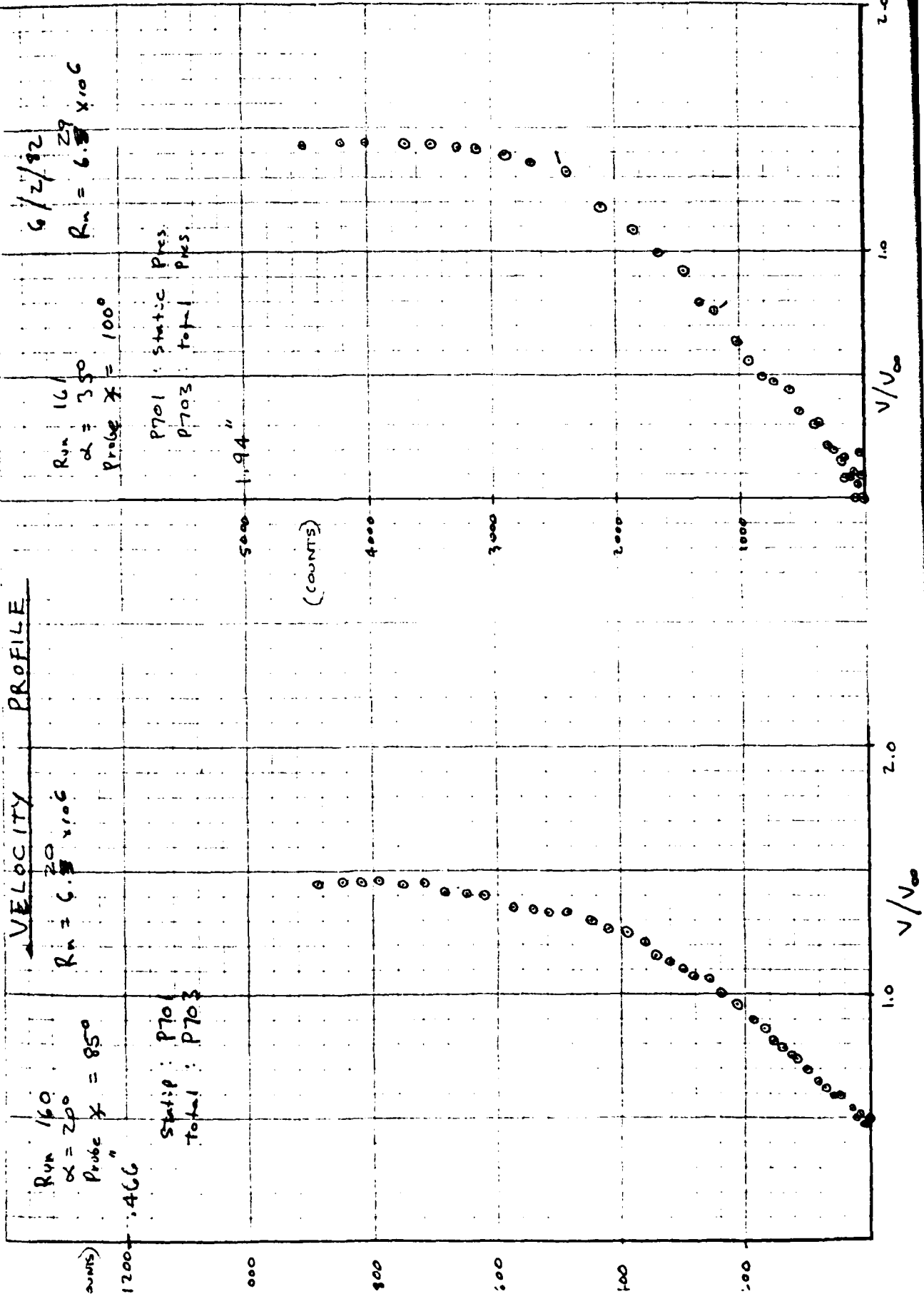
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16.

VELOCITY PROFILE



# VELOCITY PROFILE

Run 162  
 $R_n = 625 \times 10^6$   
 $\alpha = 15^\circ$   
 $Pr_{eff} \approx 80^\circ$

P701 : Static Pms.  
 P703 : total Pms.

Run 163  
 $R_n = 633 \times 10^6$   
 $\alpha = 25^\circ$   
 $Pr_{eff} \approx 90^\circ$

P701 : Static Pms.  
 P703 : total Pms.

6/3/82

ms)

1000 - 383"

800

-76-

600

400

200

(INCH)

.4

.3

.2

.1

2.0

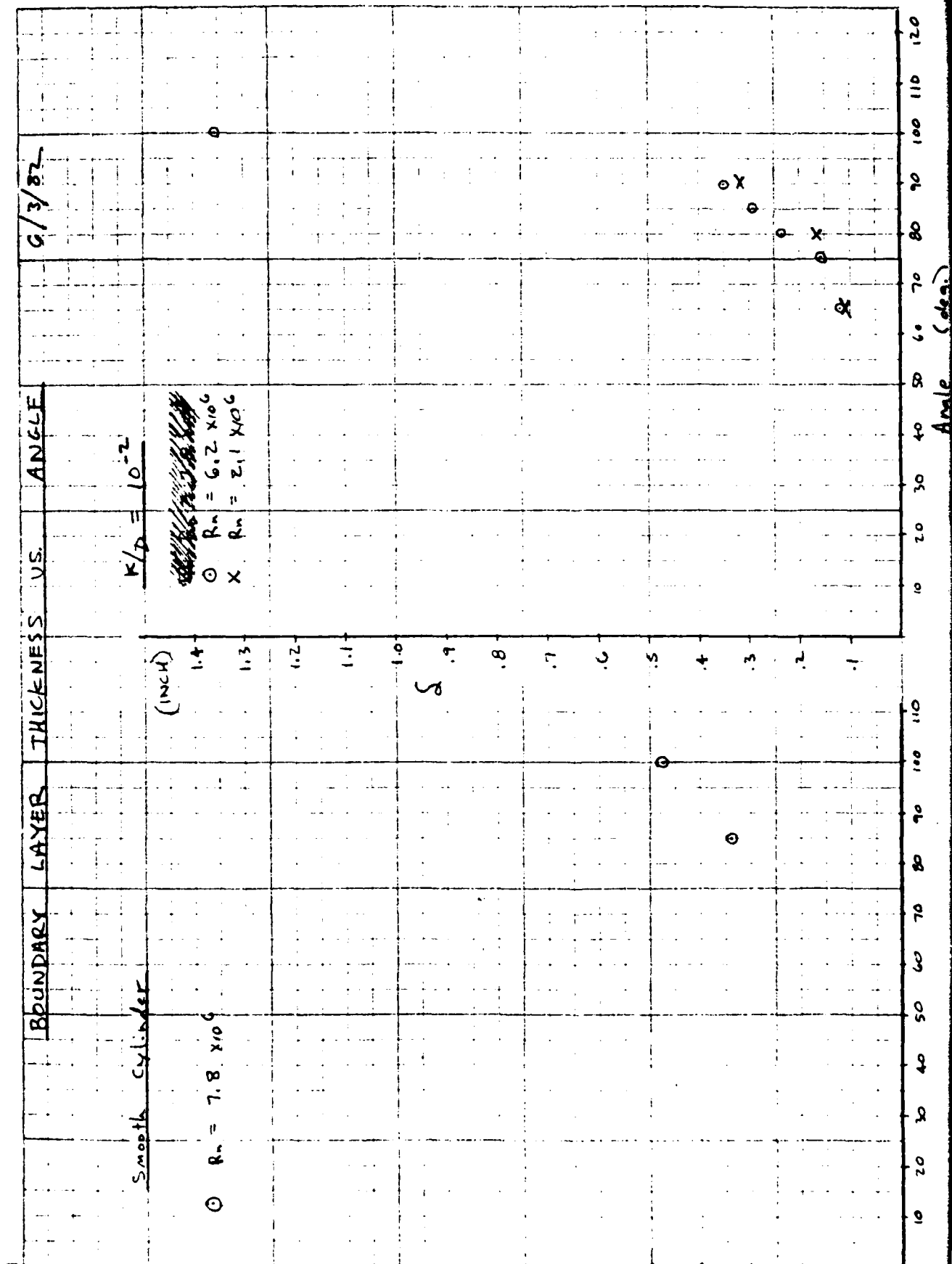
V/V

1.0

0.0

2.0

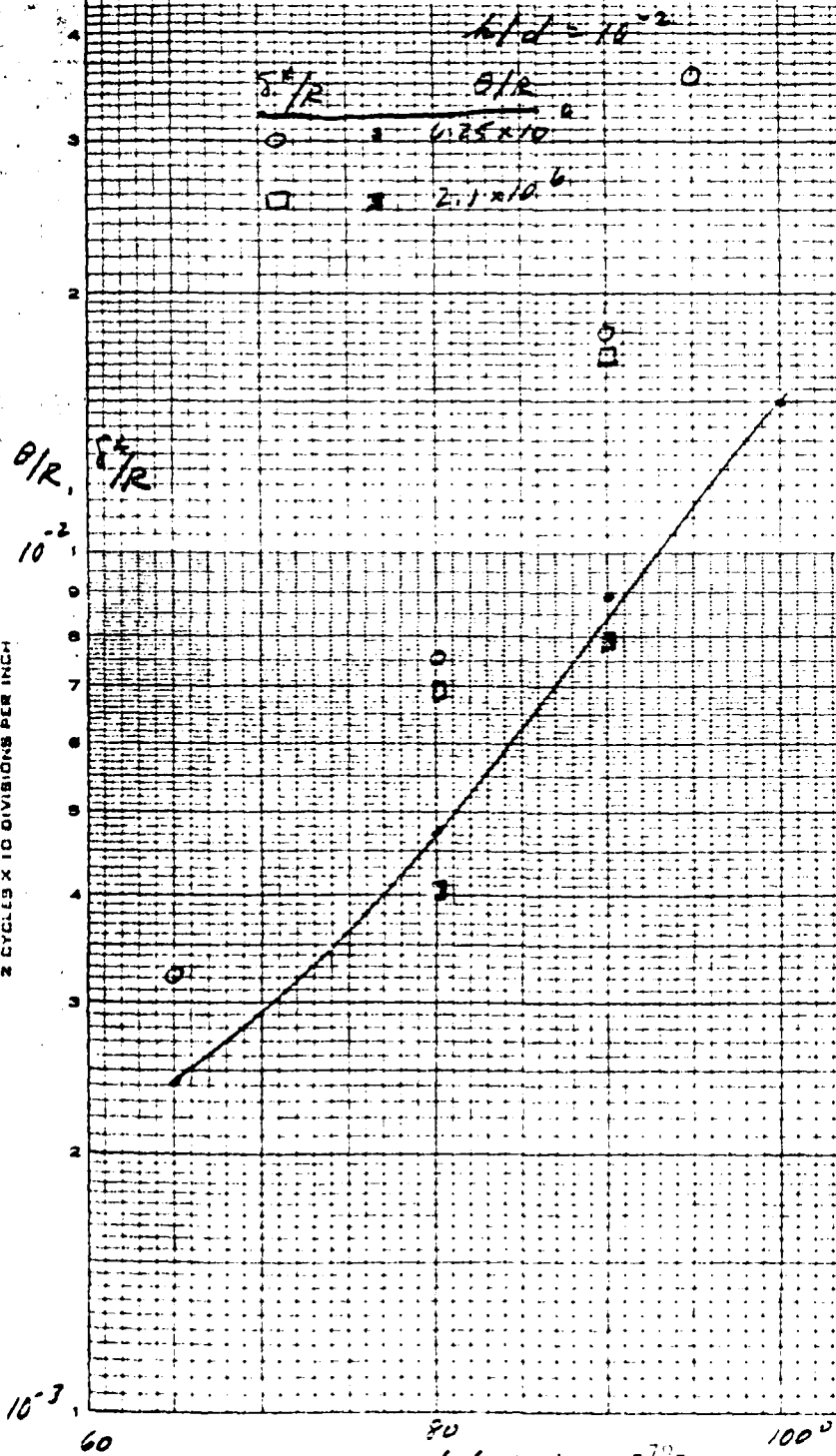
V/V





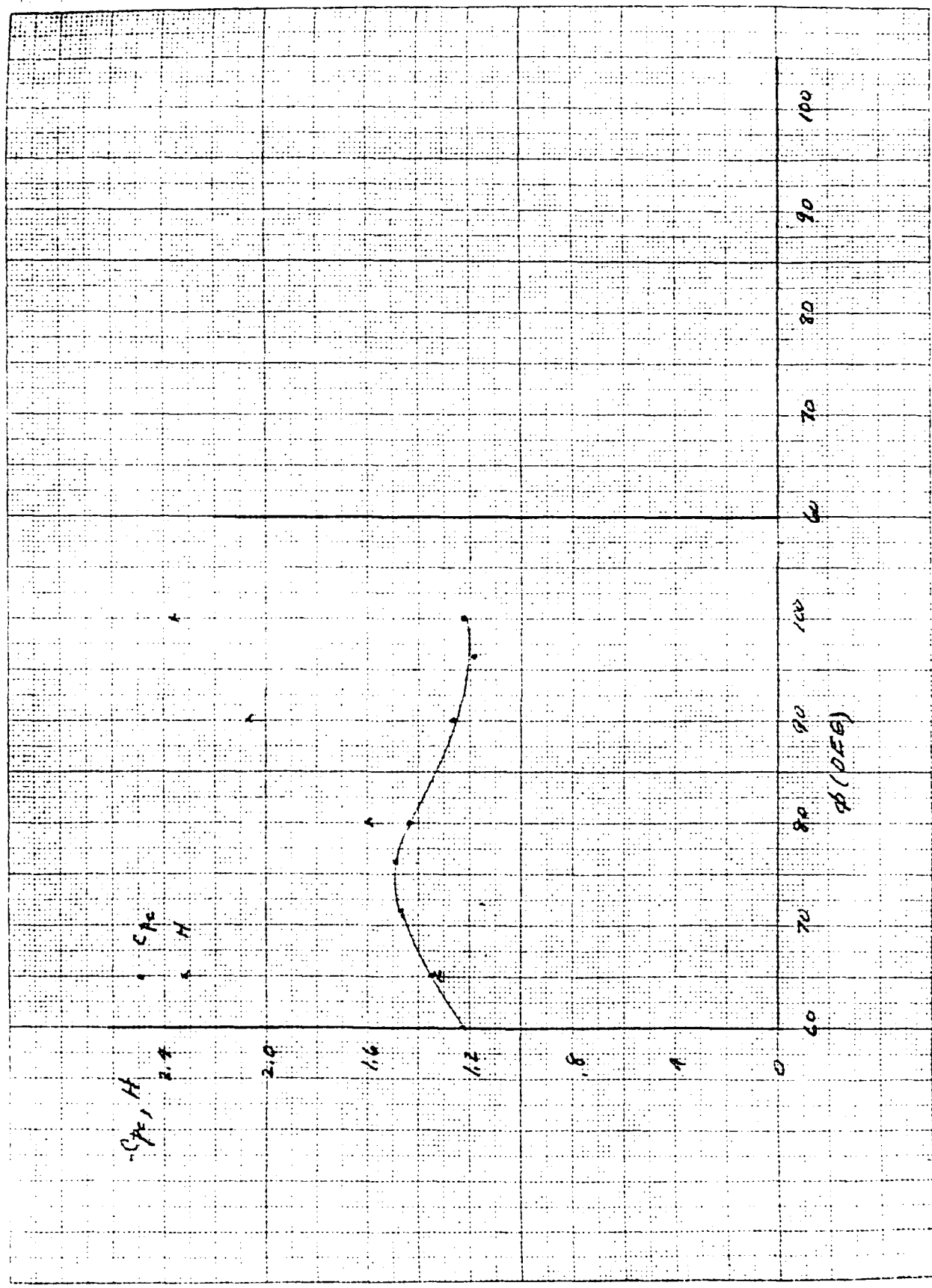
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 SEMI-LOGARITHMIC  
 2 CYCLES X 10 DIVISIONS PER INCH

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SOME PRELIMINARY BL DOODLINGS

PHI (DEG)	$\theta/RX10^3$	$\delta^*/RX10^3$	$\delta/R$	$C_F/2X10^3$	$C_F(RE_D)^{1/2}$
65	2.41	3.21	.022	9.64	24.1
80	4.75	7.59	.037	12.00	30.0
90	8.93	18.00	.063	24.00	60.0
100	15.00	36.00	.140	35.00	87.5

$$Re_d = 6.25 \times 10^6, \quad h/d = 10^{-2}, \quad d = 2R = 12.46''$$



## RECOMMENDATION

- STEADY PRESSURE DATA NEEDS FURTHER SCRUTINY
  - BAD POINTS SHOULD BE ELIMINATED FROM INTEGRATED OR AVERAGED RESULTS
  - FINAL PLOTS WITHOUT BAD POINTS REQUIRED
  - PERFORM DATA ANALYSIS
- NEED A CRITERION BASED ON VORTEX SHEDDING STRENGTH TO DEFINE PRESENCE OF PERIODIC SHEDDING
- CHECK ACCURACY OF DYNAMIC DATA WITH CORRECTED MEAN DATA: COMPLETE DATA ANALYSIS
- TURBULENT ROUGH WALL BOUNDARY LAYER ANALYSIS WITH PRESSURE GRADIENT:
  - PROFILE CALCULATIONS
  - BL INTEGRAL PROPERTIES
  - SKIN FRICTION
  - SIMILARITY IDEAS

**DATE**  
**ILME**